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JOURNAL OF THE SOCIETY OF ARTS.

No. 1357.] FRIDAY, NOVEMBER 22, 1877. [Vol. XXVII.

ONE HUNDRED AND TWENTY-FIFTH SESSION, 1878-79.

Arrangements for the Session.

The First Meeting of the One-Hundred-and-Twenty-fifth Session of the Society was held on the 20th inst., when the Opening Address was delivered by Lord Alfred S. Churchill, Chairman of the Council. Previous to Christmas there will be Four Ordinary Meetings, in addition to the Opening Meeting, and the Papers will be read by Captain Burton, Mr. J. N. Shoolbred, Mr. Hyde Clarke, and Dr. Gladstone. The subjects and dates of these papers are given below :—

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock. For meetings previous to Christmas :—

November 20.—Opening Meeting. Address by Lord Alfred S. Churchill, Chairman of the Council.
November 27.—"The Land of Midian." By Captain Richard Francis Burton.
December 4.—"Electric Lighting." By Mr. James N. Shoolbred.
December 11.—"Railways to Turkey and India." By Mr. Hyde Clarke.
December 18.—"Science Teaching in Elementary Schools." By Dr. J. H. Gladstone, F.R.S.

For meetings after Christmas :—

"The Distribution of Disease popularly considered." By Dr. Alfred Haviland.
"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By Mr. Joseph J. Pope, M.R.C.S., L.S.A.
"The Best Methods for Improving the Condition of the Blind." By Dr. T. R. Armitage.
"Indian Pottery at the Paris Exhibition." By Dr. G. Birdwood, C.S.I.

Indian Section.

The meetings of this Section will take place on the following Friday Evenings, at Eight o'clock:—

January 31; February 21; March 7; April 4; May 2 and 23.

The subjects of the papers to be read will be announced in the *Journal*.

African Section.

The meetings of this Section will take place on the following Tuesday Evenings, at Eight o'clock :—

January 21; February 4; March 18; April 1 and 29; May 27.

The subjects of the papers to be read will be announced in the *Journal.*

Chemical Section.

The meetings of this Section will take place on the following Thursday Evenings, at Eight o'clock :—

December 12; January 16; February 13; March 13; April 24; May 15.

The subjects of the papers to be read will be announced in the *Journal.*

Cantor Lectures.

The First Course of Cantor Lectures will be by Mr. W. Mattieu Williams, on "Mathematical Instruments." It will consist of Six Lectures, to be given on the following dates:—

November 25; December 2, 9, 16; January 20, 27.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Household Sanitary Arrangements." It will consist of Six Lectures, to be given on the following dates:—

February 17, 24; March 3, 10, 17, 24.

The Third Course will be by Mr. W. H. Preece, on "Recent Advances in Telegraphy." It wi consist of Five Lectures, to be given on the following dates :—

April 21, 28; May 5, 12, 19.

The following is a Syllabus of the Course of Cantor Lectures on "Mathematical Instruments," by Mr. W. Mattieu Williams:—

Lecture I.—Mathematics, "the science of quantity"—Mathematical art, the art of measuring quantities—The measurement of quantities effected by means of mathematical instruments—Importance of quantitative knowledge—The measurement of abstract quantities by figures and symbols—The measurement of magnitude or quantities of space—The measurement of direction and the determination of position—The measurement of quantities of matter—The measurement of force—The measurement of value—All measurements are obtained by comparison—A fixed standard of comparison is necessary.

Lecture II.—Standards of space-measurement, the yard, the metre, &c.—Standard of mass or gravitation, the pound, the gramme, &c.—Thermometric and Calorimetric standards—Photometric standards—Electrical standards—Standards of value. *Instruments for the Direct Measurement of Lines, Surfaces, and Cubic Contents.*—Rules, scales, tapes, Gunter's chain, compasses, callipers, gauges, micrometers, pedometers, perambulators, opisometers, &c.—The planimeter—The device of Archimedes and its applications.

Lecture III.—*Instruments for Measuring Angles and Straight Lines by Triangulation.*—Modes of expressing direction and angular measurement—Base lines—Necessity for horizontal or vertical datum—The plummet—The spirit-level. *The Theodolite taken as the typical and most complete Instrument for the Measurement of Angles by Direct Vision.*—Details of its construction—The patterns and castings—Hammering and trying, planing, filing up, smoothing and polishing of uprights, Y's semicircle, stage, &c.—The staff head—The parallel plates—The plate and limb—The horizontal and vertical axes, and precautions necessary for securing their truth—The divisions of the limb and semicircle—The verniers and magnifiers—The tangent and clamp screws—Grinding of the level tubes—The collimation of the telescope—The capture and manipulation of spiders—Wollaston's wire—The adjustment of the complete instrument—Various forms of theodolite.

Lecture IV.—The altitude and azimuth instrument—The plane table—The prismatic compass and miner's dial—The surveying cross and optical square—The mural quadrant—Hadley's quadrant—The sextant—Troughton's reflecting circle—The artificial horizon—The goniometer—The transit telescope—The geometrical uses of the clock and chronometer—The equatorial telescope. *Instruments for Levelling, and the Direct Measurement of Altitudes.*—Simple levels without telescopes—The Y level—The dumpy level—Other forms of level—Levelling staves—The mountain barometer—The aneroid barometer. *Instruments for Measuring and Rectifying Curvature.*—The straight-edge and surface-plate—Sights—How to walk straight—The tripod micrometer and the measurement of curvature—The dip sector.

Lecture V.—*Instruments for Measuring Mass.*—The scale beam—The steel yard—The spring balance—Laboratory balances—Cavendish's torsion balance for weighing the earth—Weighing the earth by plumb-line—Weighing the earth by pendulum. *Instruments for Measuring Short Intervals of Time and Great Velocities.*—Wheatstone's and Foucault's mirrors—The chronograph—The spectroscope as applied to the measurement of velocities.

Lecture VI.—*Instruments for Recording or Representing Results of Mathematical Processes.*—Plotting and Drawing Instruments.

These lectures will not be addressed to mathematicians, but the subject will be treated in simple and elementary forms; any technical term that must necessarily be used will be explained when introduced.

Additional Lectures.

A Course of Two Lectures will be given by Dr. B. W. RICHARDSON, M.A., LL.D., F.R.S., on "Some Further Researches in Putrefactive Changes," in continuation and completion of his course of Cantor Lectures given last Session.

Proceedings of the Society.

CHARTER.—THE SOCIETY OF ARTS was founded in 1754, and incorporated by Royal Charter in 1847, for "The Encouragement of the Arts, Manufactures, and Commerce of the Country, by bestowing rewards for such productions, inventions, or improvements as tend to the employment of the poor, to the increase of trade, and to the riches and honour of the kingdom; and for meritorious works in the various departments of the Fine Arts; for Discoveries, Inventions, and Improvements in Agriculture, Chemistry, Mechanics, Manufactures, and other useful Arts; for the application of such natural and artificial products, whether of Home, Colonial, or Foreign growth and manufacture, as may appear likely to afford fresh objects of industry, and to increase the trade of the realm by extending the sphere of British commerce; and generally to assist in the advancement, development, and practical application of every department of science in connection with the Arts, Manufactures, and Commerce of this country."

THE SESSION.—The Session commences in November and ends in June. The number of Meetings held during the Session amounts to between 70 and 80.

ORDINARY MEETINGS.—At the Wednesday Evening Meetings during the Session, papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed.

INDIAN SECTION.—This Section was established in 1869, for the discussion of subjects connected with our Indian Empire. Six or more Meetings are held during the Session.

AFRICAN SECTION.—This Section was formed in 1874, for the discussion of subjects connected with the Continent of Africa. Six or more Meetings are held during the Session.

CHEMICAL SECTION.—This Section was formed in 1874, for the discussion of subjects connected with Practical Chemistry and its application to the Arts and Manufactures. Six or more Meetings are held during the Session.

CANTOR LECTURES.—These Lectures originated in 1863, with a bequest by the late Dr. Cantor. There are Three Courses every Session, and each course consists generally of from Four to Six Lectures.

ADDITIONAL LECTURES.—Special courses of Lectures are occasionally given.

JUVENILE LECTURES.—A short Course of Lectures, suited for a Juvenile audience, is delivered to the Children of Members during the Christmas Holidays.

ADMISSION TO MEETINGS.—Members have the right of attending the above meetings and Lectures. They require no tickets, but are admitted on signing their names. Every Member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor and other Lectures. Books of tickets for the purpose are supplied to the Members, but admission can be obtained on the personal introduction of a Member. For the Juvenile Lectures special tickets will be issued.

JOURNAL OF THE SOCIETY OF ARTS.—The *Journal*, which is sent free to Members, is published weekly, and contains full Reports of all the Society's Proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce.

EXAMINATIONS.—The Society's Examinations now comprise the following divisions:—1. Commercial Knowledge. 2. Domestic Economy. 3. Fine Arts applied to Industry. 4. Music. 5. Technology of Arts and Manufactures. 6. Elementary. The Programme for 1879 is ready, and can be had on application to the Secretary.

LIBRARY AND READING-ROOM.—The Library and Reading-room are open to Members, who are also entitled to borrow books.

CONVERSAZIONI are held, to which the Members are invited, each Member receiving a card for himself and a Lady.

HEALTH AND SEWAGE OF TOWNS.—A Conference is held annually.

DOMESTIC ECONOMY.—A Congress is held annually.

Membership.

The Society numbers at present nearly four thousand Members. The Annual Subscription is Two Guineas, or a Life Subscription of Twenty Guineas may be paid.

Every Member whose subscription is not in arrear is entitled:—

To be present at all Evening Meetings of the Society, and to introduce two visitors at such meetings, subject to such special arrangements as the Council may deem necessary to be made from time to time.
To be present and vote at all General Meetings of the Society.
To be present at the Cantor and other Lectures, and to introduce one visitor.
To have personal free admissions to all exhibitions held by the Society at its house in the Adelphi.
To be present at all the Society's *Conversazioni*.
To receive a copy of the Weekly *Journal* published by the Society.
To the use of the Library and Reading-room.

Candidates for Membership are proposed by three Members, one of whom, at least, must sign on

personal knowledge; or are nominated by the Council. The Annual Subscription is Two Guineas, payable in advance, and dates from the quarter-day immediately preceding election; or a sum of Twenty Guineas in lieu of all further contributions, may be paid.

All subscriptions should be paid to the Secretary, and all Cheques or Post-office Orders should be crossed "Coutts and Company," and forwarded to him at the Society's House, John-street, Adelphi, London, W.C.

Persons desiring to become members should communicate with the Secretary, Society of Arts, John-street, Adelphi, London, W.C.

Calendar for the Session.

The following is the Calendar for the Session 1878-79. It is issued subject to any necessary alterations:—

NOVEMBER, 1878.

1	F	
2	S	
3	**S**	
4	M	
5	Tu	
6	W	
7	Th	
8	F	
9	S	
10	**S**	
11	M	
12	Tu	
13	W	
14	Th	
15	F	
16	S	
17	**S**	
18	M	
19	Tu	
20	W	Ordinary Meeting,
21	Th	Opening Meeting
22	F	of the Session
23	S	
24	**S**	
25	M	Cantor Lecture I. 1
26	Tu	
27	W	Ordinary Meeting
28	Th	
29	F	
30	S	

DECEMBER, 1878.

1	**S**	
2	M	Cantor Lecture I. 2
3	Tu	
4	W	Ordinary Meeting
5	Th	
6	F	
7	S	
8	**S**	
9	M	Cantor Lecture I. 3
10	Tu	
11	W	Ordinary Meeting
12	Th	
13	F	
14	S	
15	**S**	
16	M	Cantor Lecture I. 4
17	Tu	
18	W	Ordinary Meeting
19	Th	
20	F	
21	S	
22	**S**	
23	M	
24	Tu	
25	W	CHRISTMAS DAY
26	Th	Bank Holiday
27	F	
28	S	
29	**S**	
30	M	
31	Tu	

JANUARY, 1879.

1	W	
2	Th	
3	F	Juvenile Lecture
4	S	
5	**S**	
6	M	
7	Tu	
8	W	
9	Th	
10	F	Juvenile Lecture
11	S	
12	**S**	
13	M	
14	Tu	
15	W	Ordinary Meeting
16	Th	Chemical Meeting
17	F	
18	S	
19	**S**	
20	M	Cantor Lecture I. 5
21	Tu	African Meeting
22	W	Ordinary Meeting
23	Th	
24	F	
25	S	
26	**S**	
27	M	Cantor Lecture I. 6
28	Tu	
29	W	Ordinary Meeting
30	Th	
31	F	Indian Meeting

FEBRUARY, 1879.

1	S	
2	**S**	
3	M	Additional Lecture 1
4	Tu	African Meeting
5	W	Ordinary Meeting
6	Th	
7	F	
8	S	
9	**S**	
10	M	Additional Lecture 2
11	Tu	
12	W	Ordinary Meeting
13	Th	Chemical Meeting
14	F	
15	S	
16	**S**	
17	M	Cantor Lecture II. 1
18	Tu	
19	W	Ordinary Meeting
20	Th	
21	F	Indian Meeting
22	S	
23	**S**	
24	M	Cantor Lecture II. 2
25	Tu	
26	W	Ordinary Meeting
27	Th	
28	F	

MARCH, 1879.

1	S	
2	**S**	
3	M	Cantor Lecture II. 3
4	Tu	
5	W	Ordinary Meeting
6	Th	
7	F	Indian Meeting
8	S	
9	**S**	
10	M	Cantor Lecture II. 4
11	Tu	
12	W	Ordinary Meeting
13	Th	Chemical Meeting
14	F	
15	S	
16	**S**	
17	M	Cantor Lecture II. 5
18	Tu	African Meeting
19	W	Ordinary Meeting
20	Th	
21	F	
22	S	
23	**S**	
24	M	Cantor Lecture II. 6
25	Tu	
26	W	Ordinary Meeting
27	Th	Chemical Meeting
28	F	Indian Meeting
29	S	
30	**S**	
31	M	

APRIL, 1879.

1	Tu	African Meeting
2	W	Ordinary Meeting
3	Th	
4	F	
5	S	
6	**S**	
7	M	
8	Tu	
9	W	
10	Th	
11	F	Good Friday
12	S	
13	**S**	EASTER SUNDAY
14	M	Bank Holiday
15	Tu	
16	W	
17	Th	
18	F	
19	S	
20	**S**	
21	M	Cantor Lecture III. 1
22	Tu	
23	W	Ordinary Meeting
24	Th	Chemical Meeting
25	F	
26	S	
27	**S**	
28	M	Cantor Lecture III. 2
29	Tu	African Meeting
30	W	Ordinary Meeting

MAY, 1879.

1	Th	
2	F	Indian Meeting
3	S	
4	**S**	
5	M	Cantor Lecture III. 3
6	Tu	
7	W	Ordinary Meeting
8	Th	
9	F	
10	S	
11	**S**	
12	M	Cantor Lecture III. 4
13	Tu	
14	W	Ordinary Meeting
15	Th	Chemical Meeting
16	F	
17	S	
18	**S**	
19	M	Cantor Lecture III. 5
20	Tu	
21	W	Ordinary Meeting
22	Th	
23	F	Indian Meeting
24	S	
25	**S**	
26	M	
27	Tu	African Meeting
28	W	Ordinary Meeting
29	Th	
30	F	
31	S	

JUNE, 1879.

1	**S**	
2	M	
3	Tu	
4	W	
5	Th	
6	F	
7	S	
8	**S**	
9	M	
10	Tu	
11	W	
12	Th	
13	F	
14	S	
15	**S**	
16	M	
17	Tu	
18	W	Conversazione at
19	Th	South Kensington
20	F	Museum
21	S	
22	**S**	
23	M	
24	Tu	
25	W	Annual General Meet-
26	Th	ing
27	F	
28	S	
29	**S**	
30	M	

The chair will be taken at eight o'clock at each of the above meetings, except the Annual General Meeting.

The Annual General Meeting will be held at four o'clock.

PROCEEDINGS OF THE SOCIETY.

FIRST ORDINARY MEETING.

Wednesday, November 20th, 1878; Lord ALFRED CHURCHILL, Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society :—

Arbuthnot, Lieut.-Colonel George, R.A., M.P., F.R.G.S., 5, Upper Eccleston-street, S.W.
Bates, J. Walker, 5, Harrington-street, Liverpool.
Birch, Charles, 32, The Chase, Clapham-common, S.W.
Bird, Paul, 16, Hyde-park-place, W.
Bird, Samuel, 44, Belsize-park-gardens, N.W.
Birt, Alfred William, Dock-street, E.C.
Bodden, William, Oldham.
Busk, Charles Westly, 12, Vanbrugh-park, Blackheath, S.E.
Chadwick, William, Ponders-end, Middlesex.
Cook, John, Kingston-upon-Hull.
Cooper, Basil Henry, F.R.S.L., Fonthill-road, N.
Crowder, William, 2A, Evering-villas, Evering-road, Upper Clapton, E.
Datdah, Paul, Dinàrd, Ille et Vilaine, France.
Dean, Henry, 9, Milbrook-road, Brixton, S.W., and Deddington, Oxon.
De Rance, Charles E., F.G.S., 28, Jermyn-street, S.W., and Scientific Club, Savile-row, W.
Donaldson, John, Tower-house, Turnham-green.
Eastly, John, 86, Grange-road, S.E.
Edward, Charles, J.P., Park-lodge, Dundee.
Fearns, Francis Henry, Trafalgar Works, Old Kent-road, S.E., and Valentine-lodge, Peckham Rye, S.E.
Fitzroy, Major Cavendish C., 4, Cranley-place, Onslow-square, S.W.
Forsyth, William, Q.C., M.P., 61, Rutland-gate, S.W.
Froy, William Nathaniel, Brunswick Works, King-street, Hammersmith, W.
Furness, Edward, 74, Fleet-street, E.C.
Galsworthy, James, Grosvenor-road, Aldershot.
Godfrey, Albert Speed, Matson Red-house, Richmond, Surrey.
Gorzira, Cornelio, 30, Wellington-square, Oxford.
Graham, Alfred, 3rd Flat, 2 and 3, Tothill-street, Westminster, S.W.
Gray, John, Patent-office, Chancery-lane, W.C.
Gribble, William, 12, Abchurch-lane, E.C.
Hale, Charles, Lilian-villa, Barnes.
Halliday, Arthur, 92, High-street, Eton.
Hartley, General Marcellas, 19, Maiden-lane, New York.
Harvey, John James, 36, Stanhope-street, Euston-road, N.W.
Haughton, William, East India United Service Club, St. James's-square, S.W.
Hockey, Alfred Knibbs, Beccles, Suffolk.
Hughes, Ivor Edward, C.E., Milverton-lodge, Sydenham-hill-road, S.E.
Jackson, William, St. Neots, Huntingdonshire.
Joy, David, 11, Cavendish-park, Barrow-in-Furness.
Kinsman, Frederick, Indian Government Telegraph Department, Bombay.
Lloyd, Thomas, 4, Victoria-street, Westminster, S.W.
Lornie, John, F.S.S., Rosemount, Kirkcaldy, N.B.
Lucas, Arthur, 37, Duke-street, St. James's, S.W.
McAndrew, Major-General George, 34, Russell-road, Kensington, W.
McEvoy, Captain Charles Ambrose, 18, Adam-street, Adelphi, W.C.
McMurrough-Kavanagh, Frank, 9 and 10, Exchange-arcade, Manchester.
Marten, Henry John, C.E., 4, Storey's-gate, Westminster, S.W., and Parkfield-house, Wolverhampton.
Middleton, William John, 41, Belsize-avenue, South Hampstead, N.W.
Miller, Alexander, The Fishery, Chepstow.
Minami, Tamots, Imperial Japanese Consulate, 84, Bishopsgate-street, E.C.
Moses, C., Worsley-house, North Ormesby, Middlesbrough.
Parker, William Colton, Whitehall Club, S.W.
Randall, W. F., 31, Stowe-road, Shepherd's Bush, W.
Richardson, Thomas Henry, Middlesbrough.
Ritchie, Frederick James, 25, Leith-street, Edinburgh.
Roberts, William Brittain, 4, St. Stephen's Church-villas, Shepherd's-bush, W.
Sedgwick, Alfred Owthwaite, North-end-house, Watford.
Seeley, Alfred, The Ferns, Onslow-road, Richmond-hill, Surrey.
Simms, James, Old Charlton, near Woolwich, S.E.
St. George, Percival Walter, City Surveyor's Office, Montreal, Canada.
Stower, Herbert S., 48, Lansdowne-road, W.
Sutton, Thomas Ashley, Irkdale Chemical Works, Smedley-road, Manchester.
Swanston, George J., Board of Trade, Spring-gardens, S.W.
Turbervill, Malcolm W., 1, Everett-terrace, Walton-on-Naze, Essex.
Wardle, Thomas, 62, St. Edward-street, Leek.
Watts, Edwin Richard, 123, Camberwell-road, S.E.
Webster, Richard Everard, Q.C., 2, Pump-court, Temple, E.C.
Wesley-Church, John, H.M. Patent Office, Southampton-buildings, W.C.
Whalley, Cuthbert Wm., 14, Beaufort-sq., Chepstow.
Whateley, John, Lichfield.
Williams, George Joseph, 17, Cavendish-place, Cavendish-square, W.
Wood, Edward George, 74, Cheapside, E.C.

The CHAIRMAN delivered the following—

ADDRESS.

By the flattering suffrages of my colleagues, I am again placed in the important position of Chairman of the Council of this Society; and in that character the duty devolves on me of opening the Session, and sketching out, so far as is possible, the probable course of action the Society will take during the coming year. You have had before you, in the report of the Council presented to the members at the Annual General Meeting in June last, a complete narrative of the work done by the Society in the past Session ; it is therefore unnecessary for me to recapitulate what was then reported. Inasmuch, however, as a great deal of that work is continuous in its character, and necessarily incomplete, it may be taken for granted that the Society will busy itself with carrying on to their legitimate ends those special movements which it has undertaken, as well as its usual ordinary proceedings. I may, however, take this opportunity of informing the members that, acting on the letter which H.R.H. the Prince of Wales addressed to the Council in April last, suggesting the co-operation of this Society and the Royal Commission for the Paris Exhibition, the Council have been enabled to assist 206 selected Artisans to visit and study the Exhibition, representing over 40 different branches of industry. Reports from these men are now coming in, and it is intended to publish them forthwith. The Council have had great satisfaction in having been able to render assistance to his Royal Highness in bringing this important work to a successful issue.

A special work which the Council has on hand, and which it is intended to carry on, is that comprehended in the Congresses on Health and Sewage of Towns, on Water Supply, and on the teaching of Domestic Economy in the elementary schools of the kingdom. Already, as you are aware, there have been three Congresses or Conferences held under the title of "Health and Sewage of Towns," and with marked success. The Water question, one of national interest, was taken up on the suggestion of his Royal Highness, the President, as embodied in his Royal Highness's letter addressed to the Council in January last, and it formed the subject of a separate Congress. This question is, however, so important in a national point of view, and still excites so much interest, that the Council have—wisely, in my opinion—determined that it shall not be dropped, but shall take a place in the programme of the next Congress on "Health and Sewage of Towns." The scope of the fourth Congress, to be held in May next—following the advice of Mr. Stansfeld, the active president of it—will be extended so as to embrace the discussions of all these subjects; interpreting "Health" in its broadest sense, and not merely as connected with the sewage of towns only. In accordance with the resolutions passed at the Water Supply Congress, the Council will endeavour to find a convenient opportunity of bringing before her Majesty's Government the absolute necessity of dealing with this question in a national sense, and taking steps for rendering "the great natural resources of the kingdom," to use the words of his Royal Highness, available "for the general body of the nation at large." It is evident that, in dealing with this question, the saving of our rivers from pollution forms a very important element, but not the only one, as other sources of supply have to be dealt with. Doubtless you are aware that an Act has been passed with a view of preventing this pollution of rivers, but, unfortunately, its provisions are so hampered with conditions of all kinds, to say nothing of its permissive character in many respects, that, for all practical purposes, the Act may be considered as but a dead letter. The evils have been repeatedly pointed out by Royal Commissions and Parliamentary Committees, and the time has arrived when something practical should be taken in hand. Difficulties no doubt exist, but it is the duty of a statesman to overcome difficulties, and I think it can hardly be said that in the present case they are insuperable. But rivers are not our only sources of supply; lakes, both artificial and natural, as well as underground waters, must be resorted to. Each district has its own specialities and needs its own special treatment, but this does not preclude the adoption of a general system, sufficiently elastic to meet the varying requirements of each. Local administration, with its local knowledge and local interests, might, as it seems to me, fairly be entrusted with the general treatment and conservancy of the river basin, and with the consideration of the claims of each district on the sources from whence a supply might be taken; whilst a supervising authority might be vested in the hands of a competent central body, to advise, control, and direct. The central body might collect into one focus all the information already accumulated in reference to these various matters—but buried, so to speak, in Blue-books, and other stores of information—and, where needed, seek by the necessary surveys and examination such further information as may be required from time to time to supplement what is already known. It should also be prepared to supply such data on application from any district authority needing it. Whilst on this subject, I may state that the Committee on Water Supply have had prepared, for reference, a catalogue, or digest, of all that has hitherto been done in the way of inquiry and collection of information on this subject. This information is at present scattered in Parliamentary Blue-books, various official Reports, Transactions of societies, and other works. Such a Digest, or collection of information, has never hitherto been prepared, and it cannot fail to be of great assistance to all interested or engaged in investigations connected with water and water supply. Whilst speaking of the pollution of our rivers, let me advert to the Thames, into which we are pouring all the filth of this metropolis, whilst other towns are precluded by Acts of Parliament from casting their sewage into their neighbouring streams. Public opinion at the present time points to this anomaly, but whether anything will be done to remove it remains to be seen. How this removal should be effected, and what are the details which should be adopted, it is not for me to say; it is clear, however, that discussion on all such matters cannot fail to assist in the solution of a question which, I venture to think, cannot much longer be postponed.

While, however, the sewage question is necessarily involved in the purity of our rivers, there is another aspect in which it deserves our most serious attention, viz., its effect upon the health of our population. To this comparatively little attention is given—though I am glad to observe that public interest is being aroused—and neither the builders of houses nor those who live in them are sufficiently alive to its importance. We construct costly and efficient sewers, but, as a rule, we take little care how we make use of them. We connect our houses with them in such a way as to bring the unhealthy gases direct into them. It is not sufficient that a town should be well drained or well sewered; these are simply means to an end, but the end is too often neglected. Unless the house arrangements for connection with them are carefully made, it may be safely stated that the very sewers may become a curse rather than a blessing. It is to be feared that such is the case, to a very considerable extent, in a large number of our towns, not omitting the metropolis. Too little attention has hitherto been paid to this matter. The occupier takes his house upon faith, and not until the deadly effects of imperfect connections manifest themselves by impaired health on the part of himself or his family, is any heed given to the cause. It may be that no actual case of typhoid or diphtheria manifests itself, but disease is there, nevertheless, insidiously pervading all subject to its influence, and bringing on a lowered state of vitality, which renders the sufferer less capable of resisting the attacks of any unfavourable circumstances which may arise. An increased death-rate is the result. A greater supervision in the first instance is needed, to secure the proper connection of the house with the drains. It may

be said that this is so obvious a matter of interest to the occupier that he will look to it himself. Experience shows that such is not the case. In the first place, the public generally are not alive to the evil; and, in the next place, in the great majority of instances, the occupier has nothing to do with the building of the house, and even if he has, or desires to investigate before he takes his house, the subject is so little understood, and the difficulties of getting anything like accurate knowledge of the state of the drainage—necessarily, from the nature of the case, covered up—so great, that the occupier takes his house upon faith, and suffers accordingly. With a view of diffusing information, especially in connection with this subject, the Council have a proposition before them for establishing a Sanitary Section, with a Committee especially appointed to take charge of it, who, in the intervals between each Congress, shall meet, and, amongst other things, make such arrangements as may be calculated to aid members of the Society in obtaining information connected with this special subject, as well as reliable reports as to the sanitary condition of their houses. It remains yet under consideration whether this proposition will be adopted.

The last two or three years, indeed, I might say the last year, have been so fruitful in inventions and projects beyond all others, that I doubt not there will be found plentiful work to engage the Society's attention. The telephone came upon us like a miracle, followed by the phonograph and the microphone in quick succession. How far these two latter inventions may or may not be brought to play a part in the practical affairs of every day life is yet uncertain. If the telephone has not yet become in this country the household instrument which was anticipated, on the other side of the Atlantic, in the United States of America, its use is almost unlimited. Why there should be this difference I cannot pretend to say, but the fact is so; whether the monopoly of telegraphy in the hands of the Government has had an unintentional influence in producing this result in this country may fairly be matter of discussion. The monopoly, in reality, places no bar whatever to its private use by private individuals, whilst there is a wide-spread belief that there is some difficulty in the way on the part of the Post-office authorities. That telegraphy in the hands of the Post-office has flourished and been extended in its use beyond what any public companies would have given us in the same time is undoubted, and I, for one, have no desire to dispute this, but I am by no means clear that it is due to the monopoly of sending messages for hire throughout the kingdom; and I am inclined to think that, great as the extension of the telegraph system, both by public and private wires, has undoubtedly been in the hands of the Post-office, it would have been equally great without the monopoly, while a large addition in the way of private telegraphy would have taken place side by side with it, had the field been more free to mercantile enterprise as well. The latter would have acted as a stimulus to the former in the use of improvements, especially in the way of instruments, including the telephone. Take the private wires of the present day. It is true there is no real monopoly, either in the putting up or working such lines, except so far as the conveyance of intelligence for hire is concerned, but for some reason or other private wires are, as a rule, put up by the Post-office, and rarely by private individuals, and are worked on a rental system. The Post-office adopts the very admirable A B C instrument of Wheatstone, and supplies no other; the result is, that although there are several instruments at the present time of an improved character, printing the message in Roman characters, and so giving a permanent record of it, whilst the other is evanescent, the Wheatstone instrument is still retained. It is true that anyone is at liberty to purchase and use such improved instruments in connection with Post-office wires for his private purposes, but this involves an outlay, and deters many who, for the facility of a rental, and the dealing with one body only instead of two, are induced to take the more imperfect instrument. The Post-office very naturally objects either to change the system or to have several systems at work. Again, owing to the Post-office monopoly, claimed by the Post-office for the conveyance of intelligence for hire, whether by letter or by telegraph, individuals are checked in their endeavours to extend the use of the telegraph, while in America it is largely at work. There a central office connects itself with subscribers all over the area of a city. Telegrams, prices, and such like are placed in a transmission instrument in the central office, which at once, by means of a receiving instrument on the premises of the individual subscriber, turns out the message, neatly printed on a slip of paper, into a basket. A fire alarm, a messenger call by telegraphy, is also in daily use there. A system on this principle is, under some very special arrangement with our Post-office, in use at our Stock Exchange in the City, where prices are telegraphed and delivered in print into the brokers' offices at frequent periods of the day. The privilege, however, is special, and confined to a very limited area, and has been obtained, doubtless, by powerful influence brought to bear on the Post-office. Is there any reason why so great an advantage should not be made general and open to any who might desire to bring such a system into general use? In Glasgow, an enterprising individual has, in conjunction with the merchants of that city, established an office at the Chamber of Commerce somewhat of this character. He is in connection by wires, put up by himself, with a large number of subscribers, to each of whom he supplies mercantile information from time to time, price lists and so on, and on receiving a signal he can at once place any two of his subscribers in direct telegraphic communication with each other, giving thus a great facility of intercourse between firms at a distance from each other in the city or its suburbs. A system of fire alarms also has just been commenced in Glasgow, and it is to be hoped that the above system may be extended to the metropolis, and to our large towns in the provinces. So far it may be said the Post-office does not interfere to check private enterprise, but there is an impression the other way, and in the uncertainty of what may or may not be legal little is attempted. These are matters I would commend to the consideration and enterprise of our members.

There is another subject which, though it has

advanced most marvellously in the last few years, is still deserving of attention of our enterprising members; I allude to the steel manufacture. Steel is now taking the place of iron in almost every direction. In 1851 the whole annual make of steel in the United Kingdom was 50,000 tons, and from the expensive character of its manufacture its use was confined to a very limited class of articles, principally tools and cutting instruments; now we have single firms capable of turning out weekly something like 2,000 tons. And how has this arisen? The first stimulus that was given in this direction was by our member, Mr. Bessemer, followed by another of our members, Dr. Siemens, and latterly by another member, Sir Joseph Whitworth, all three of whom have reflected honour on the Society as recipients of the Society's Gold Albert Medal, bestowed on them in recognition of the high services they have rendered to the industry and commerce of the world. It is true, in speaking of steel, we must bear in mind that, whilst the 50,000 tons spoken of as the annual out-put in 1851 were of a special high character, in fact an article *de luxe*, and especially suitable for one class of manufacture only, the modern steel is of a varied character, and produced specially adapted for a large variety of purposes, to which it may be applied. Indeed, it is one great merit of these modern processes, that it is in the power of the manufacturer to supply any quality of steel that may be specified. In the early days of these new processes there were difficulties in obtaining a steel which was perfectly uniform in its character, and engineers were cautious in introducing it into their specifications as a thoroughly reliable material. But this difficulty has now disappeared. For rails, for ships' plates, and for bridges and structures of all kinds, this modern steel is now superseding iron, and the Board of Trade have within the last twelve months sanctioned its use for structures over which they have a supervising power, by acknowledging its superior strength to iron, and its fitness for engineering purposes, laying down rules for its adoption, recognising its superior strength over iron, and thus stimulating its substitution for that metal. The Admiralty admit its use for ships' plates, and doubtless our mercantile marine will not be slow to acknowledge its merits. Indeed, I am told, some shipowners have already commenced its use, its superior lightness as compared with iron admitting additional weight of cargo to be carried, and thus earning a freight as regards heavy goods which would in a very short time cover any extra expense caused by its use. An eminent engineer has said that the days of iron are numbered, and even goes so far as to say that fifty years hence "iron will be unknown." This, perhaps, is a somewhat broad assertion; and one of your Council qualifies the statement, declaring, in a lecture before the Royal Institution, that the time is shortly coming when, except for mere handicraft blacksmith's work, wrought iron will no longer be in use. Steel rails, I am told, can be bought at the present time for a price very little higher than those of iron, whilst it must be borne in mind that, at the very lowest calculation, the life of a steel rail is double that of an iron rail for any equal number of tons passed over. There are, however, instances tending to show an endurance in steel of from four to eight times that of some kinds of iron. Of course, quality must be taken into consideration. If the production of wrought iron is to be cheapened, I am told that this must be looked for in the conversion of the ore direct into wrought iron; but in looking to this it must not be omitted from your consideration that the conversion of the ore direct into steel is also close at hand. All these are matters for the serious attention of the members of a Society like this.

It may be expected that, in addressing you on the present occasion, I should say something on a subject which, at this time, is exciting great attention, viz., the electric light, but inasmuch as a paper on this subject is coming before you shortly, I will content myself with pointing out that, though it has only of late been brought specially before the public in this country, it has been in actual commercial use on the other side of the water, in France, for upwards of two years. So long ago as the winter before last several factories and commercial establishments were successfully using it, and have continued to do so since. Though, no doubt, there is considerable room for further invention before it can come into general use, especially for domestic purposes, the trial has been carried on so long in Paris, that it may be said to have passed beyond the range of experiment. How far it will, in the end, supersede gas, is a matter on which I will not venture to prophesy, but this, I think, I may with a tolerable approach to certainty, say, that for a very long time to come gas will hold its own, the more especially as we are told that large improvements in its manufacture and use are at hand, with a view both to cheapness and improved illumination. That the electric light for many purposes is available at the present time, and will be brought largely into use, there can be but little doubt, whilst its beauty, efficiency, and brilliancy must be admitted on all hands.

The French International Exhibition has just closed, and I may congratulate the British Department in having made a most successful show. Whether it is in matters of art and taste, or in matters of mechanical contrivance and machinery, opinions on all sides agree that Great Britain and her Colonies have held their own in the great industrial contest of nations. The book of Jury Awards, with its list of gold and silver medals to our people, sufficiently confirms this view. If other nations have run us hard in mechanism and manufactures, we may congratulate ourselves in the enormous stride this country has made on the matter of art and taste. Whilst in 1851 our artistic productions would not bear comparison with France, I am assured by those on whose judgment in such matters I may rely, that we have no reason to be dissatisfied with our progress, but on the contrary may congratulate ourselves with having placed the supremacy of France in considerable danger. I think I may fairly claim merit for our Government Schools of Art in this respect, and for the vast encouragement given by our Government in the establishment of the South Kensington Museum. This example in Art is a promising augury of what may follow in the encouragement of Science, as now afforded by the Government in stimulating its teaching throughout the country, and what may be expected if the teaching of Technology be like-

wise supported, whether by Government or the enlightened liberality of public bodies, to which I refer later on. Whilst, however, we plume ourselves in the high position we take either in industry or arts, whilst we pride ourselves on the vast strides we make in inventions and material progress, let us not forget the drawback of the sad and serious catastrophes which accompany them. Colliery explosions, collisions at sea, on our rivers, and by land on our railways, form a striking comment on all our efforts. Here is a wide field for our inventors and engineers to exercise their talents for prevention. In relation to this, let me draw attention to what is doing in the way of breaks for stopping railway trains. I am not going to offer any opinion on the merits of the various continuous breaks which are placed for choice before our railway companies, but, looking at what these can accomplish, and thus tend to diminish the number of accidents from collision, it would seem to me that the time has come when the Government might step in, and, by making authoritative experiments, compel the adoption of some system by the companies, or, at all events, lay down some positive regulations, by which breaks fulfilling certain special conditions must be adopted for the safety of travellers. One of your Council, Capt. Douglas Galton, has lately, with the assistance and at the expense of a railway company, made a number of experiments on this subject, with very valuable results in the elucidation of principles which govern the operation of breaks, and some of them are of a novel and important character. It would be well if such experiments could be repeated and confirmed by some Government authorities, who might then lay down rules and regulations which should govern our choice of breaks, the use of which might then be made compulsory by law. It is feared that until something of this kind is done, but slow progress will be made in the adoption of what, under any circumstances, must be costly arrangements for the safety of the travelling public. The block system of signalling on our railways has no doubt contributed much to the safety of our travellers by rail, and its extension is daily taking place; but it must be remembered that a block system which does not combine with it interlocking signals does but half do its work; witness a fearful accident of recent date on one of our leading lines of rail, where the block signal was in perfect operation, while independent points were under the control of a shunter, permitting traffic to cross the line duly signalled "clear."

As regards collisions at sea or in our rivers, an important investigation has of late been made, which tends to show that collisions of this kind have arisen from a mistaken notion of the action of the rudder when the working of the screw is reversed, and the vessel still continues on her course. The able experiments of Professor Osborne Reynolds, assisted by eminent sailors and engineers, go to show that when this reversal takes place, the action of the rudder to turn the ship cannot be relied on. It is said that the collision of the two German ironclads in the Straits was due to this hitherto unknown effect. This is a subject I would commend to the consideration of both sailors and engineers, as having a most important bearing on the safety of our ships.

In remarking on the great progress which is being made in the present time in all our arts, we must not be unmindful of the source whence these arise. The discoveries of science, which follow in quick succession, are daily laid hold of by those who seek to turn them to account in practical work, for the benefit of our daily wants, and that nation will best take its place in the struggle for superiority which best trains the mass of its working population to understand and take advantage of those discoveries in science which are placed before them. This view the Society of Arts has ever held and endeavoured to foster. Its Technological Examinations have been established for this very purpose; and the promotion of technical education is a subject which has been frequently treated of from this chair. For the last few years the Society has waited with some anxiety to see whether any practical results were likely to come of the much talked of action of the City Companies, and I am glad now to see that a definite step has been taken by the establishment of the "City and Guilds of London Institute," for the advancement of Technical Instruction. At the head of the executive committee of this body is the well-known member of our Council, Mr. Bramwell, under whose able direction I am sure it cannot but prosper. From the action of this institute we may fairly hope to see great improvements in the means available to our artisans for obtaining Technical Education. It starts into being well endowed and influentially supported, and I sincerely trust it may be successful in carrying on that great work which, it must never be forgotten, was commenced by this Society of Arts. The precise line of action to be taken by this institute we do not yet know. You may remember that the Committee of the Guilds reported on the special reports obtained by their direction, and that the last step taken before the recess was to lay both the special reports and the committee's report before the Common Council, and to obtain its approval thereon. The report recommended the establishment or the assisting of trade schools, and the erection eventually of a suitable building in London for the teaching of advanced students and the training of teachers. Since this report was issued, there has been a slight change in the circumstances, for the Commissioners of the 1851 Exhibition have made a proposal to erect on their property a building suitable for the use of a museum, and for other purposes connected with technical instruction, but not more precisely defined. I cannot doubt that this will make some difference in the ultimate plans of the City Institute; and, indeed, if it appears probable that the idea of the Commissioners will be carried out, it must follow almost of necessity that the notion of a similar, and, in fact, a rival building, will be abandoned. If this be so, the Committee of the Institute will, I imagine, be thrown back on the course of action by which the only practical results have yet been attained—the endowment, in one form or another, of local schools. Should they attempt this on any extended scale they will assuredly find the need for some general system of inspection and examination, such as that of our own Technological Examinations. Now, I should be very sorry to give the idea that we, the Society of Arts, want to get rid of these examinations; we

have attained with them a certain measure of success, and we think we see a prospect of very much greater success, but at the same time we have not the means of developing them as they might be developed, and I know the Council would be glad to see a system, on which so much thought and care have been expended, flourishing, as I am convinced it might do, under the care of some institution which could devote to it the special attention it requires. I shall, therefore, be glad to hear that the Committee of the City Institute are likely to ask us to act upon the resolution passed some time ago by the Council, to the effect that we should be ready to hand over the Technological Examinations to any properly-constituted body as soon as some such body was ready to take charge of them. This resolution was passed in answer to an application from the then committee of the guilds, and at that time there was no institution in existence which which was in a position to take over the examinations. The new Institute is beyond all question such a body, and I hope that negotiations may be entered upon which may result in a transfer of our Technological Examinations to them. Should they, however, prefer to direct their energies in other directions, it will be our duty to continue this important division of our examination system, and I have no hesitation in saying that the gratifying progress it has made during the past few years gives us abundant reason to anticipate still further success in this direction.

I am well aware that the objection has been raised, that what is wanted is not so much examination as actual instruction. As our examinations were originally constituted, there may have been, at least, an apparent truth in this, but whatever ground may have existed, has now certainly been removed by the grants made by the Clothworkers' Company for payments on the results of the examinations. It has been found, by long experience, that the readiest means of inducing teachers to train classes, has been to ensure them a certain result if those classes are properly trained; and the only means that has yet been devised for testing the results of teaching, is an examination of the persons taught. This we do to a certain extent by our Technological Examinations, and having done so, we pay the teacher in actual proportion to the value of his work as thus tested. The real importance, therefore, of our plan is, that it ensures that teaching, at least up to a certain fixed standard, is given, and that all money paid actually represents a definite amount of education, a definite number of students taught. But the question of payment by results has long since been decided, nor should I have re-opened it here, had I not understood that many who are not familiar with the working of the system on a large scale, have raised objections to its application upon the smaller scale, on which alone we have yet been able to employ it. Its real value is that it offers the readiest inducement to teachers, the most accurate means of estimating the value of their teaching, and the surest method of paying them accordingly. It has, indeed, other uses, as giving a certificate of competency, but these are only secondary to its main object of providing the largest amount of teaching at the smallest cost. This was throughout the intention of the originators of the system. But it has only been for the last two years that the system has really been in full action, or in a position to be fairly judged by its results.

On the whole, then, I think I may say that the prospects of Technical Education were never brighter. We have two wealthy public bodies, the Commissioners of the 1851 Exhibition, and the new Institute of the City Companies, considering how best they may bestow their funds for its advancement. We ourselves are steadily working in the direction in which we started, and are now—after no small labour in originating this great movement—equally ready to carry on this work, or to hand it over to any who can show themselves better qualified and equally earnest. With all surrounding circumstances thus favourable, we may look hopefully forward to a future, now not far remote, when a great blank in our system of education shall be properly filled up, and the great class of workers, upon which so much of our national prosperity depends, shall no longer depend on accident or good fortune for the means of acquiring that knowledge by which alone practical handicraft skill can be suitably directed and wisely applied.

The Chairman then presented the following Medals and Prizes:—

The Society's Silver Medal:—

To Thomas Wills, F.C.S., for his lectures on "Explosions in Coal Mines."

To John Yeats, LL.D., for his paper on "Higher Commercial Education."

To Alexander Graham Bell, for his paper on "The Telephone."

To J. Bennett Lawes, F.R.S., for his paper on "Freedom in the Growth and Sale of the Crops of the Farm, considered in its Bearing upon the Interests of Land-owners and Tenant Farmers."

To W. H. Preece, for his paper on "The Phonograph, or Talking Machine."

To R. M. Gover, M.R.C.P., for his paper on "Dietaries, in their Physiological, Practical, and Economic Aspects."

To Basil H. Cooper, B.A., for his paper on "Egyptian Obelisks and their Relation to Chronology and Art."

To H. B. Cotterill, for his paper on "A Year on the Nyassa, with Notes on the Slave Trade, and on the Prospect and Means of opening up the Surrounding Country."

To Sir Joseph Fayrer, M.D., K.C.S.I., for his paper on "The Destruction of Life in India by Wild Animals."

To W. T. Thornton, C.B., for his paper on "Irrigation Regarded as a Preventive of Indian Famine."

To Col. J. T. Smith, R.E., F.R.S., formerly Master of the Mint, Madras and Calcutta, for his paper on "The Depreciation of the Value of Silver, with Especial Reference to the Exchange between India and England, and Suggestions for a Remedy."

To F. C. Danvers, for his paper on "Agriculture in India."

To James Mactear, for his paper on "Some Recent Improvements connected with Alkali Manufacture."

The Society's Silver Medal and £10 10s. to Messrs. Letcher Bros, of St. Day, Cornwall, for their Guinea Set of Blowpipe Apparatus.

The Society's Bronze Medal to Carl Osterland, of Freiberg, Saxony, for the excellence of the manufacture of his Blowpipe Apparatus.

His Royal Highness the Prince Consort's Prize of Twenty-five Guineas, to GEORGE WILLIAM IRONS, aged 29, of St. Stephen's (Westminster) Evening Classes, in the Civil Service, who has obtained the following First-class Certificates in the present and three preceding years:—

1875. English Language.
,, Arithmetic.
,, Theory of Music.
1876. Political Economy, with the First Prize.
1877. Housekeeping and Thrift.
1878. Clothing.
,, Commercial History and Geography, with the Second Prize.
,, Shorthand.
,, Cookery.

The Council Prize (for Female Candidates) of Ten Guineas, to EMMA DICKES, aged 28, of the Birkbeck Literary and Scientific Institution, student, who has obtained the following First-class Certificates during the specified period:—

1876. Clothing, with the First Prize.
1878. Housekeeping and Thrift.
,, Cookery.

MISCELLANEOUS.

ELECTRIC LAMPS.

At the present moment, the subject of electric lighting is attracting so much attention, and so much desire is expressed for information thereanent among many who have no special pretension to scientific training or experience, that perhaps no excuse need be offered for an attempt to describe, in a thoroughly popular manner, the different varieties of apparatus which are now being employed for the purpose of producing light by means of an electric current. At the outset, it may be as well to warn off technical readers, who are at once informed that they need look for nothing in the following description which is not well known to all whose duties or inclination have induced them to turn special attention to the matter. Apart from these, it is probable that there are many readers of the *Journal* who have not made themselves familiar with the theory of electric lighting, and to whom such an exposition as is here attempted may be not unwelcome. For the present it is proposed to treat only of the lamps employed. The electricity itself may, of course, be generated either by a galvanic battery, or by a machine driven from any suitable prime mover. The former source has been long employed, but it is the latter which is now invariably used for electric lighting on the large scale.

There are many varieties of machines, differing widely from one another in their details. Some of the more important varieties have already been described in this *Journal*,* but for our present purposes we shall have enough to do to consider the apparatus used to transform electricity into light, without touching on the generators which produce electricity, or rather transform into electricity the mechanical energy which in its turn has been derived by the steam-engine or other prime mover from heat.

Whenever a voltaic circuit, the circuit joining the two poles of a battery or magneto-electric machine, and along which the current flows, is ruptured, a bright spark is seen. If the two ends of the broken circuit are of carbon, the spark is specially vivid. If the current be of sufficient strength, the spark becomes a brilliant star of light, which remains so long as the pieces of carbon are not too far removed from one another. This star or band of light is, from its shape, known as the voltaic arc. Whenever the voltaic arc is formed between two pieces of carbon, the carbon is rapidly consumed, and consequently the space between the two pieces increases until it is too great to allow the arc to be formed. The result is that the light disappears. It is therefore necessary to provide some apparatus which shall keep the carbons at the same distance apart, however fast they may waste away, so that the space between the two may always be constant. It is also a point of great importance that the distance apart of the carbons should be precisely that at which the most brilliant light is produced, since there will always be one particular distance at which there is such a result, and any excess or diminution of which has an injurious effect on the light. The various devices intended to effect this object are known as electric lamps or regulators, and it is by the use of one or other of these devices that all electric illumination has up to the present been effected. Certain other apparatuses, noticed below, depend for their action on other principles, but whatever may be the future use of these it cannot be said that they have as yet established their practical value. Some of them are much too recent for any opinion to be formed about them.

The first and most obvious idea was to give such a motion to the carbons as would cause them to approach in a corresponding rate to that in which they were consumed. This is a good deal easier in theory than in practice. A uniform mechanical motion is by no means sufficient. The rate of consumption of the carbons is constantly varying. It varies with the strength of the current (and this in its turn is affected by any variation in the distance between the carbons) and with the nature of the carbons themselves. A further complication is introduced by the fact that the "positive" carbon wastes about twice as fast as the "negative" carbon, so that, to keep the light always in the same position, a corresponding motion must be given to each. The position of the carbons must therefore be controlled automatically by the current itself, so that as the light grows weaker they must be drawn apart or brought together, till that position is obtained at which the light has its greatest intensity. To effect this many very beautiful and ingenious arrangements have been devised. It would be impossible to give an account here of all these, but a few typical lamps may be described, to illustrate the principles employed.

One of the earlier and best known is that of M. Duboscq. In this, as in nearly all electric lamps, the carbon is in the shape of two rods, mounted vertically in the same straight line, one over the other, the upper end of the lower carbon touching the lower end of the upper carbon. The holders carrying the carbon rods slide up and down so as to separate or bring together the ends of the rods. In the stand, on which these holders are mounted, is a clockwork motion which slowly moves the upper holder down and the lower up, at about the same rate as the ends are consumed, thus the wasting away of the ends, and their approach to one another, proceed together at such a rate that they are kept at about the same distance apart. But, as stated above, the unvarying regularity of this mechanical movement is not what is required. The movement must accommodate itself to the variations of the electric current. To this intent the power possessed by the electric current, of magnetising a piece of iron round which it flows, is rendered available. The current in its path is led through a coil of insulated wire surrounding a core of soft iron. Whenever the current flows, this iron becomes a magnet, stronger or weaker according to the strength or weakness of the current. When the ends of the carbons touch, the current flows without interruption, and its effect is then greatest on the magnet. As

* Many of the machines employed were described in an article in the *Journal* for Sept. 28th, 1877, p. 979, vol. xxv.; and in Dr. Paget Higgs' paper, *Journal* for April 5th, 1878, p. 392, vol. xxvi.

the carbons are separated, the obstacle to the free flow of the current is increased, and its effect on the magnet grows weaker and weaker until when the carbons are so far apart that the voltaic arc can no longer be formed, the current is interrupted, and the iron core ceases to be magnetised at all. It is evident that the magnet may be caused to act on the end of a lever, so as to release the clockwork when the magnet is feeble, and lock it when it is strong. Suppose the carbons in contact, and a current of electricity passed through the apparatus. The upper carbon is raised (in the earlier lamps by hand), and the voltaic arc shines out. The carbons burn away, and as the widening space between them offers increased resistance to the current, the magnet grows weaker, till it ceases to attract the lever which locks the clockwork, and the carbons are brought nearer. Instantly the magnet is again brought into action, and the clockwork movement stopped. So the process goes on. In all the lamps now made on this principle a second movement is added, which acts in the opposite direction to the other, coming into play when the carbons are too near. This serves to separate the carbons when they touch, and thus enables the lamp to be lighted by simply turning on the current. The lever operated by the magnet is made to release either of two detents, or to lock both when the lamp is working properly.

The Duboscq lamp has loug had a rival in the Serrin, and by this it has now to a great extent been superseded. In the Serrin the upper carbon holder is made of considerable weight, so that it serves by its descent to drive the apparatus. By means of a traiu of wheels it raises the lower carbon at the required rate, as it slides down itself. The lower carbou holder is also attached to a little frame which is drawn down by an electro-magnet and raised by a spring. The lamp being in position, with the carbons touching, a current is sent through it. The magnet is rendered active and attracts the frame, lowering slightly the lower carbon, and so causiug the appearance of the voltaic arc. As the magnet is weakened, the spring raises the frame, aud consequently the lower carbon, thus, as the carbons approach, causing the current to act more strongly on the magnet, and enabling it to draw down the frame. There is thus a series of small oscillations up and down which corresponds with the variations of the electric current. Concurrently with these oscillations is a steady movement of the carbons, tending to bring them together, and correspondiug with the wasting away of their ends. By regulating the distance between the poles of the magnet and the "armature" attracted by it, the action of the magnet, and, consequently, the distance between the carbons, can be minutely regulated. The lamp is also fitted with a locking device, which comes into action when the carbons are touching and no current is passing, but is released as soon as the current is sent through the apparatus.

Another plan is employed in the Siemens-Halske lamp. In this, also, the weight of the descending upper carbon holder is caused to raise the lower holder, bnt the separatiou of the carbons is effected by a ratchet-wheel, worked by a lever, to which an oscillating motion is given by an electro-magnet. As the current acts strongly on the magnet, it causes it to attract the end of the lever, which then moves the ratchet-wheel one tooth forward, and the carbons are thereby slightly separated. But the lever in its movement also brings together two metallic point iu the paths of the current, which allow it to pass direct to the carbons without traversing the coils of the magnet. Instantly the magnet is rendered inoperative, and the armature, released thereby, is drawn back by a spring. The metallic points are separated, aud the current once more is obliged to take the longer route round the magnet. There is thus a constant oscillation of the lever, depending on the strength of the curreut, aud so the carbon points are removed from each other at a rate depending on the strength of the current, while they are constantly brought near by a uniform motion approximately corresponding with their waste.

In the lamp, again, of M. Archereau, a still different device is employed. In it is utilised the power possessed by a galvanic current flowing round a spiral, of attracting into the centre of the spiral a bar of iron placed partly within it. The lower carbon carrier is mounted on the upper end of an iron rod, the lower end of which enters within the core of a bobbin of insulated wire, through the coils of which the current is led on its way to the carbon. The rod is supported by a weighted cord, which, when the lamp is not at work, keeps the top of the lower carbon in contact with the bottom of the upper carbon. As soon as the current flows, the iron rod is drawn down into the coil, and the carbons are thus slightly separated; the cousequent weakening of the current prevents the further separation of the carbons, and they are thus maintained at the required distance apart. It is, of course, necessary that the weight should be carefully regulated to correspond with the magnetic influence of the bobbin. Though there are many obvious imperfections in this simple arrangement, it is yet frequently used for lecture and such-like purposes.

One other regulator of this class also deserves notice from its extreme simplicity, that of Mr. Browning. In this the upper carbon holder slides down by its own weight, and when the lamp is not at work, the upper carbon rests on the lower carbon. The upper carbon is raised to cause the production of the voltaic arc, and is thus held by a keeper attracted by an electro-magnet. As the space between the carbons lengthens, the weakening current acts less powerfully on the magnet, the keeper is released, and the carbon falls till its approach to the lower carbon enables the current to act more forcibly on the magnet, and the keeper, again attracted, grips the carbon, again to release it as the current falls off. It is needless to say that this simple device does not pretend to compete with the elaborate and sensitive lamps of Serrin and Duboscq. In more recent lamps by the same maker, the weight of the upper holder is utilised, as in the Serrin, to move both carbons, and the movement of the lower one is controlled by an electro-magnet. In the latest form of all, a spring is used instead of the weight, so that the lamp can be set in any position.

The above are all examples of the same type of regulator. In all of them two rods of carbon, set end to end, are moved towards each other at such a rate as to compeusate for their gradual consumption. The description of them may, perhaps, be sufficient to give a general idea of the conditions to be fulfilled, and of the only successful way in which till lately any attempt was made to fulfil them. Before passing on, however, to speak of other—and all receut—systems, it may be as well to refer to the regulators of Lontin and Mersanne, both of which are now attracting some attention. The Lontin regulator is is a modified form of the Serrin, the modifications being intended chiefly to enable several lights to be set in the same electric circuit. The Mersanne lamp, unlike those above described, is set with its carbons horizontal, and the movement is obtained as in the Siemens machine, but in a different manner, from a little electro-motor, worked by the magnet. It has the advantage of allowing the carbons to be fed in continuously without stopping.

The Rapieff system does uot differ greatly in principle from the preceding, but has the distinguishing characteristic of employing a pair of carbons, arranged like the limbs of a V, instead of a single rod both at top and bottom. The rods are all fed forward by weighted cords, and there is a lever operated by an electro-magnet which raises and lowers the frame carrying one of the two pairs of carbons, so as to adjust their position as usual.

In another class of lamps, discs or slabs of carbon are substituted for the rods, the discs or slabs being arranged so that the voltaic arc is formed between their nearest

points. Some of the earliest lamps were constructed on this principle, and it has lately been revived by several inventors. M. Regnier has recently brought out a lamp in which two discs of carbon, closely approaching at one point of their edges, revolve slowly, so as to bring continually fresh surfaces to the point of combustion. By means of a regulating device on the same principle as those previously referred to, the discs are brought together or separated as the current varies. This lamp is chiefly interesting as having led to the construction of a modified form of it, which really acts on a different principle, and is referred to below. Differing still further from any yet mentioned, but perhaps to be placed in this class, is the Wallace-Farmer lamp. In this, two oblong slabs of carbon are set, one above the other, with their edges adjacent. The lower slab is fixed. The upper one is capable of sliding up and down, so as to rest with its lower edge upon the upper edge of the lower carbon. The frame which carries this upper carbon is raised and lowered by an electro-magnet. The current, on being sent through in the usual way, brings the magnet into action, and this raises the upper carbon from the lower. The voltaic arc immediately forms—not along the whole length of the long slit or opening between the edges of the slabs—but at the point, wherever that may be, where they approach most nearly. The carbon is consumed at this point, and the arc shifts to the next nearest point, and so on till it has eaten away the whole length of the edge and broadened the opening so far that the current can no longer cross the intervening space. Then the lamp goes out, or is readjusted by hand. There is thus no regulator, but the inventor relies on the length of time that elapses before the carbon is consumed along the whole length of the edge of each slab.

From the last named we naturally come to that remarkable invention which has been the principal means of drawing public attention to the electric light, the so-called "candle" of Jablochkoff. As in the Wallace lamp, there is no regulating mechanism, but the required object is attained in a perfectly different and original manner. Two rods of carbon are set side by side with an intervening layer between them of china clay or plaster of paris. Imagine a section taken along the length of an ordinary lead pencil so that there is left only the lead with a thin strip of wood on either side. The wood represents the carbons, and the lead the plaster of paris, in a Jablockkoff "candle." When it is lighted the arc forms across from the end of one strip to the end of the other, the intermediate substance being fused. As the carbons burn down, the plaster of paris between their ends is burnt also, and so the whole candle burns slowly away. It will be remembered that to form the voltaic arc it is necessary that the carbons should touch, and then be separated. To fulfil this condition, the upper ends of the carbons are connected by a thin strip of carbon, so thin that the current in first passing through it burns it away. This has the same effect as if the carbons were first caused to touch and then separated.

But the voltaic arc is not the only source of electrical light, though it is by far the most vivid. It is not necessary to actually interrupt the circuit to obtain light. If in the course of a circuit along which the current is steadily flowing there is introduced any substance which, while allowing the current to pass, yet offers considerable resistance to its passage, heat is produced, and under certain conditions, the substance becomes incandescent and gives out light. Thus, if portion of a circuit be of thick copper wire and portion of fine platinum, the platinum may be made to glow with a white heat, and even be fused, while the copper is not sensibly warmed. Many inventors have endeavoured to construct lamps on this principle, but as yet with only a moderate amount of success. M. Jablochkoff in this way renders incandescent a slab of kaolin (china-clay), by sending through it a current of an induction coil. Several inventors have rendered a thin rod of carbon incandescent, while it was enclosed in a receptacle filled with nitrogen, so that it was prevented from burning away, as would be the case with carbon heated to a white heat in the air. Quite recently M. Werdermann has shown some experiments in which the end of a carbon rod is thus rendered incandescent in the air, but the rod is fed forward as fast as it is consumed. He employs a large bun-shaped piece of carbon, the round side of which is turned downwards. Against the centre of this lower side rests the top of a thin rod of carbon which, by means of a weighted cord, is pressed up into contact with the larger slab. A short distance down from the top of the rod is a metal contact, by which the current enters the rod. It traverses the short distance to the top of the rod, passes into the large carbon, and away in the usual manner. The short piece of thin rod offering a much higher resistance to the current than the rest of the circuit, it becomes incandescent, and burns away, but contact is kept up by the rod being continually forced upward by the weight. A somewhat similar device is employed by M. Regnier, who has, in one form of his disc-lamp, substituted a rod for one of the discs. He, unlike M. Werdermann, places his thin carbon uppermost, and allows it to rest on the edge of the revolving disc.

RIVERS POLLUTION ACT.

The seventh annual report of the Local Government Board for 1877-8 has just been issued. The Board, in August last, brought under the notice of the Sanitary Authorities of the United Kingdom the provisions of the Rivers Pollution Act, and have warned them by a circular as follows:—

The Sanitary Authority are doubtless aware that it has been competent for them to enforce the prohibition against putting solid matters into streams from the date of the passing of the Act.

Offences against the Act.—Offences against the Act are divided in four classes, according as they consist of the pollution or obstruction of streams:—

1. By the solid refuse of any manufactory, manufacturing process, or quarry, or any rubbish or cinders, or any other waste, or any putrid solid matter;

2. By solid or liquid sewage matter;

3. By any poisonous, noxious, or polluting liquid from any factory or manufacturing process; or

4. By the solid matter from any mine in such quantities as to prejudicially interfere with the due flow of the stream, or by any poisonous, noxious, or polluting solid or liquid matter from any mine, other than water in the same condition as drained or raised from the mine.

In proving the pollution of the stream, or interference with its due flow, in the first class of cases, evidence may be given of repeated acts which together cause the pollution or interference, although each act, taken by itself, may not be sufficient for that purpose.

It will be an offence of the second class, except in certain exceptional cases mentioned in the Act, to cause to fall or flow, or knowingly permit to fall or flow, or to be carried into any stream, any solid or liquid sewage matter.

The Board are desirous of specially drawing the attention of the Sanitary Authority to the provisions in relation to sewage pollutions, inasmuch as any infringement of them will render the Authority liable to hostile proceedings under the Act, on the part either of other Sanitary Authorities, or of any person or body of persons aggrieved by the commission of the offence.

In determining whether or not such an offence has been committed, it should be noted that a marked dis-

tinction is drawn between the cases in which the sewage is conveyed into the stream along channels, the construction of which had not been commenced at the time of the passing of the Act, and those in which it is so conveyed along channels then already existing, or in process of construction. In the former case it will be an offence against the Act for any Sanitary Authority to cause or permit the discharge into any stream of any solid or liquid sewage matter. In the latter an offence will not be deemed to have been committed if it can be shown to the satisfaction of the court having cognisance of the case that the best practicable and available means are used to render the sewage harmless. Moreover, in this class of cases, the power has been given to the Board of suspending, in any particular instance, for a limited period, the operation of this portion of the Act beyond the twelve months allowed by the statute, provided they are satisfied, after local inquiry, that further time ought to be granted to the Sanitary Authority for the purpose of enabling them to adopt the best practical and available means for rendering the sewage harmless.

In connexion with offences of this class it should be stated that where any Local Authority, or any rural or urban Sanitary Authority, have been empowered or required by any Act of Parliament to carry any sewage into the sea or any tidal waters, nothing done by such Authority in pursuance of such enactment will be deemed to be an offence against the Act.

As regards pollutions from factories or manufacturing processes, a distinction is drawn similar to that already referred to with respect to sewage pollutions, between the cases where the liquid finds its way into the stream along a channel used, constructed, or in process of construction at the date of the passing of the Act, or any new channel constructed in substitution thereof, and having its outfall at the spot, and those in which it is conveyed into the stream along a channel not falling under either of the above descriptions. In the former cases an offence against the Act will not be deemed to have been committed, if it can be shown to the satisfaction of the court having cognisance of the case that the person complained of is using the best practicable and reasonably available means to render the liquid harmless.

With respect to pollutions from mines, an offence will not be deemed to have been committed if it can be shown to the satisfaction of the court that the persen complained of is using the best practicable and reasonably available means to render the polluting matter harmless; and it must be observed that it is immaterial in this case whether the channel by which the discharge is effected was or was not constructed or in process of construction before the passing of the Act.

The attention of the numerous towns and townships of Yorkshire and Lancashire may be called to the circular, and they may be reminded that they are liable to hostile proceedings under the Act if they fail in their duty; unless, therefore, they conform to the law, they may not only expect that legal proceedings and sequestration will follow, but they may also expect the President of the Local Government Board, with the *posse comitatus*, will come down and do the work for them.

CORRESPONDENCE.

THE ELECTRIC LIGHT AND THE LONDON SMOKE NUISANCE.

I look forward with much interest to the forthcoming paper at our rooms, on the electric light question. Although I have always held that electricity, sooner or later, was destined to become the light of the future, still my faith in coal gas is so strong, that I have doubled my stake in gas shares since the scare began. I have done so because I can see that coal gas is destined to become the cooking and heating power of the future. An arrangement of this kind would exercise an important influence on the domestic life of the community. With gas cooking, ladies could, without inconvenience, become expert cooks, and thus solve one of the greatest problems of our domestic economy. Again, as we should have no dusty and sooty grates to clean, we should be able to live with fewer domestics. Dr. Down informs me, that at his great institution at Hampton Wick, he does all his warming and cooking by gas, and although his gas bill is £500 a year, and gas 5s. the 1,000 cubic feet at Hampton Wick, he saves money by the use of gas in the place of coal, as he is enabled to do with probably six fewer servants. That warming and cooking by gas can, under the best management, be effected cheaper than by coal, many know from experience. If, then, this can be demonstrated, and our great gas companies will become domestic gas-fitters, and supply their customers with the best possible apparatus at the least possible price, not only will gas shares continue to be an excellent investment, but our domestic comforts will be greatly increased, our social position improved, and the great smoke of London may then become abolished. As it is calculated that two millions sterling a year of property is destroyed by the London smoke, we have, in this fact, an immense incentive to the substitution of gas for coal fires. George Wyld, M.D.

12, Great Cumberland-place, Hyde-park,
November 13, 1878.

NOTICES.

THE JOURNAL.

Arrangements have been made for the transmission of the *Journal* in future entirely by post. All the copies of the *Journal* are now posted before the evening post of the Friday in each week, and members should receive them at least by the first morning post on Saturday. It is specially requested that any irregularity in the receipt of the *Journal* may be at once notified to the Secretary.

MEETINGS FOR THE ENSUING WEEK.

Mon.... **SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Mattieu Williams, "Mathematical Instruments." (Lecture I.)
Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. Discussion on the Paper read last Session by Mr. R. W. P. Birch, on "The Use of Sewage by Farmers."
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. Rev. J. P. Farler, "Usambara, East Africa, and the Adjoining Country."

Tues.... Metropolitan Scientific Association, 160a, Aldersgate-street, E.C., 7 p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. 1. Adjourned discussion upon the "Avonmouth, Belfast, and Whitehaven Harbour and Dock Works." 2. Mr. Wilson W. Phipson, "The Heating and Ventilating Apparatus of the Glasgow University."
Anthropological Inst., 4, St. Martin's-place, W.C., 8 p.m. 1. Mr. A. L. Lewis, "The Evils Arising from the Use of Historical National Names as Scientific Terms." 2. Prof. Daniel Wilson, "Some American Illustrations of the Evolution of New Varieties of Men." 3. Dr. Henry Muirhead, "Left-Handedness."

Wed. ... **SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Captain R. F. Burton, "The Land of Midian."
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Mr. C. F. Keary, "The Earthly Paradise of European Mythology."

Thur ... Meteorological, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. George James Symons, "Rain, Snow, Hail, and Atmospheric Electricity."

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,358. Vol. XXVII.

FRIDAY, NOVEMBER 29, 1878.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

TECHNICAL EDUCATION ON THE CONTINENT.

The following correspondence on this subject has passed between the Secretary of the Society and Her Majesty's Foreign-office.

6th November, 1878.

My Lord,—I have been instructed by the Council of this Society to apply to you, with a view of obtaining information as to the state of technical education in foreign countries.

In 1867, a circular was addressed to her Majesty's Ministers abroad, desiring them to collect and forward information on the systems of technical and industrial education in foreign countries. The result of this was a large Blue-book, published in 1868, and containing a great deal of valuable information on the subject. Since that date very great advance in technical education has been made, in many countries besides our own, and it would be of considerable value if the reports published in 1868 could be supplemented by a second series, bringing the information down to the present date.

The Society of Arts, as your Lordship is aware, has for some years carried on a system of technical examinations, which form, indeed, almost the only attempt to promote technical education in this country, and they are anxious to collect all possible information, with a view to the development of their own system, and for the use of the increasing number of schools and other public bodies which are now directing their attention to this important subject.

The Council, therefore, venture to hope that your Lordship will recognise the desirability of completing and bringing down to the present time the work commenced in 1868, and that you may see fit to give instructions which may lead to the preparation of a second volume, similar to the one already published and referred to above.—I am, my Lord, your Lordship's obedient servant,

P. Le Neve Foster, *Secretary.*

The Right Hon. the Marquis of Salisbury, K.G.

Foreign-office, November 19th, 1878.

Sir,—I am directed by the Marquis of Salisbury to acknowledge the receipt of your letter of the 6th instant, suggesting the expediency of the collection, through her Majesty's representatives abroad, of further particulars relating to Technical Education in Foreign Countries, for presentation to Parliament in continuation of the Blue-book on the above subject, which was published in 1868; and I am in reply to state to you, for the information of the Council of the Society of Arts, that this matter shall receive Lord Salisbury's consideration.—I am, Sir, your most obedient, humble servant,

T. V. Lister.

The Secretary to the Society of Arts.

NATIONAL TRAINING SCHOOL FOR MUSIC.

The following resolution has been passed by the Council:—

"It seems desirable to the Council of the Society of Arts, that in any future competition for scholarships at the National Training School for Music, those competitors who have not obtained a scholarship, but have been declared by the examiners to be eligible to enter the school as scholars, should receive certificates of their competency and eligibility, and that it shall be competent for any persons interested in any competitor who has received such a certificate, to found, within three months, a scholarship expressly devoted to the support of such scholar."

SCHOOL OF WOOD-CARVING.

With a view of encouraging the art of Wood-Carving in this country as a branch of the Fine Arts, the Council propose to apply to that object a grant placed at their disposal by the Drapers' Company, for promoting Technical Education, as they are at present in a position to secure the services of that eminent Florentine artist, Signor Bulletti, to take charge of the classes.

Messrs. Gillow and Co. have, with a view of aiding this national object, secured the use of a suitable house wherein to commence operations. They will also lend the necessary plant and models, and undertake to secure a sufficient amount of work for a year. On this basis it is hoped that a School of Art Wood-Carving may be established.

The Council will select and pay the fees for six months of four day students, who must undertake to attend during the whole of that time from 10 to 1, and 2 to 5, *at least*; and of four evening students, who must attend from 7 to 9, *at least*. Students must provide themselves with their own tools.

The Council reserve the right to cease paying the fees of any students whose instruction it appears useless to continue on account of their inattention or incapacity.

All Candidates for these Studentships must have passed the 2nd Grade Art Examination of the Science and Art Department in Freehand Drawing, at least. Those who have some knowledge of Wood-carving, or have passed in the other subjects of the 2nd Grade Art Certificate, or in Drawing from the Antique and the Figure, Architectural Drawing or Designing, or in Modelling, will be preferred.

Candidates should send in their names at once, with particulars of their qualifications, such as the date and the place of examinations passed by them, to the Secretary of the Society of Arts.

SECOND ORDINARY MEETING.

Wednesday, November 27th, 1878; Robert Rawlinson, C.B., Vice-President of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Allsup, William James, F.R.A.S., 5, Eastcombe-villas, Blackheath, S.E.
Haddan, John Lawton, 25, Great George-street, S.W.
Humm, Moses, 707, Commercial-road, E., and Chester-lodge, Loughton, Essex.
Marsland, Robert, 21, Grosvenor-street, Camberwell-road, S.E.
Mercer, Francis Moutier, 59, Bishopsgate-street Within, E.C.
Preece, W. H., Telegraph Department, General Post-office, E.C., and Gothic-lodge, Wimbledon.
Preston, Richard, Tottington, near Bury, Lancashire.
Soames, J. K., Thames Soap Works, Greenwich, S.E., and 21, Vanbrugh-park, Blackheath, S.E.
Walker, Walter Frederick, 3, Moore-park-villas, Walham-green, S.W.

The paper read was—

MIDIAN AND THE MIDIANITES.

By Captain Richard Francis Burton.

Allow me, after the fashion of novelists, to open with an *inscenesetzung*; after which my audience will be able to answer the queries, "Midian," where is it? and what is it?

To those who read their Bibles the "land of Midian," is a household word; "vexing the Midianites" and "Midianitish women" are familiar terms. But perhaps you do not know how hazy, upon the subject of the grand old land, before my trip to North-Western Arabia, in the spring of 1877, were the *literati*, the press, and the reviewers, who claim to educate their public; how they proved themselves in this case to be blind leaders of the blind.

"Midian" was indeed a *vox et preterea nihil*—a voice, a mystery. All the knowledge concerning it was confined to a few Biblical points. For instance, Midianites, merchantmen, bought Joseph from his brethren, and sold him in Egypt (Gen. xxxvii., 28). Moses, flying from the face of Pharoah, dwelt in the land of Midian, or the "east country" (Exod. ii. 15), and there married the daughter of Jethro, the priest (B.C. 1491). Despite this alliance, there was war between the kindred peoples, when the Hebrews, led by the Great Law-giver (B.C. 1452), burned the "cities and the goodly castles" of Midian, and carried off a splendid spoil of gold, silver, brass (copper or zinc), tin, iron, and lead, with vessels of gold, chains and bracelets, rings, ear-rings, and tablets" (Numb. xxxi., 22, 50-54). After a lapse of two centuries (B.C. 1249), the Midianites again grew powerful, and their revenge upon their terrible kinsmen ended in the second Midianite war. I need hardly tell you how the sword of the Lord and of Gideon slew the Ishmaelite kings, Zebah and Zalmunna, with some 135,000 warriors, and won so much gold that Gideon "made an ephod thereof, and put it in his city" (Judges viii., 24-27). After this crushing blow, the Midianites fade out of Holy Writ, and you hear of them only in the effusions of the Hebrew prophets and poets. The land of these noble old Bedawin knows them no more.

Allow me to quote a few specimens of divergent opinion upon the subject of "Midian." The classical authors of Greece and Rome utterly ignore the word, and include the country under the well-known term "Nabathæa." The mappers of Josephus, the historian, a countryman and contemporary of St, Paul, propose to settle all difficulties by splitting Midian into two Midians. The mediæval Arab geographers are mostly at variance; some, however, assign to Madyan the limits which will presently be proposed. Coming down to our modern day, Voltaire, the noble Frenchman who created religious liberty in France for Europe and the world, and who had "de l'esprit comme tout le monde," made Midian a "sandy region which may have contained some villages." He adds, it was a "canton of Idumæa, beginning north with the Arnon torrent (Wady Mújib), and ending south with the torrent Zared (Willow valley), lying among the rocks, and on the eastern shore of Lake Asphaltitis (the Dead Sea); it is thus about eight leagues long by a little less in breadth, aad it is now held by a small horde of Arabs." You will see how thoroughly erroneous is all this. Later still, some of our popular books prolonged "Midian" into Sinai; whilst others, again, either knew it not, or projected it into impossible places. The map attached to Andrew Crichton's well-known "History of Arabia" (published 1834), ignores "Midian," and supplies the whole tract with only a single name—"Moweylah." Professor Palmer ("Desert of the Exodus," p. 527) would "identify Midian with the extensive ruins of El-Midayen, a station on the Darb el Hajj, between Damascus and Mecca, three days distant from the latter town." This Orientalist goes much too far south. A reviewer in the *Pall Mall* (June 7th, 1878) makes "Midian" extend "from the north of the Arabic Gulf (Lake of El-'Akabah), and Arabia Felix (which, the ancient or the modern?) to the plains of Moab." He goes as much too far north, intruding upon Idumæa proper (Edom) which lies between Midian and Moab. Marvellous to relate, we find the irrepressible Lieut. C. R. Conder, R.E. ("Tent Work in Palestine," Bentley, 1878) declaring "the hosts of Midian were no doubt the ancestors of the modern Bedouin." This theory is about on a par with that of the Russians in the 13th century, who believed that the Tartars, with "their four-cornered faces," were the ancient Midianites coming in the latter days to conquer the earth. Even those who have visited the seaboard give no certain sound. My last predecessor was the lamented Dr. Charles Beke. In some seventeen places, he mentions "Madian," the city; but of the northern and southern, the eastern and western limits of "Midian," the country, nothing. Thus the famous old land became, like Italy of the last generation, and like modern India and Turkey since the Congress, one of the late Prince Metternich's "geographical expressions."

So much for the outer world. The modern Midianites, on the other hand, the Bedawin who now hold the soil, give a precise topographical definition of its limits; and, as some of them have held it during the days of the Byzantine Empire, I claim high authority for their catholic and constant tradition. The "Arz Madyan" of the Arabs begins north with the fort of El-Akabah, the Elath

or Eloth of the days of Solomon (N. Lat. 29° 28′), at the head of the dangerous Gulf so named. It extends south to the fort of El-Muwaylah and its great watercourse, the Wady Surr (N. Lat. 27° 40′). These frontiers, absolutely fixed, would give the Egyptian province a latitudinal length of 108 direct geographical miles. The Bedawin, again, are as precise in their definition of the breadth as of the length. All the Tihámah ("Lowlands") between the sea and the double maritime range, the Gháts of North-Western Arabia, are "Madyan;" and the depth varies between 24 and 35 miles. The country east of this wavy meridian belongs geographically to El-Nejd (the "Uplands"); and, politically speaking, it is Syrian. Note that "Arz Madyan" the country, must not be confounded, as many have done ("Madiān in Midian" p. vii.; introduction to Dr. Beke), with "Bilád Madyan;" the latter is the ruined city on the eastern shore of the 'Akabah Gulf, about one third of its length from the "Gate," or straits which connects it with the Red Sea.

The whole seaboard south of Fort El-Muwaylah, as far as the Hejáz, the Holy Land of the Moslems containing the sacred cities of Mecca and Medina, has, absolutely, no generic name. The Bedawin, who luxuriate in exuberant nomenclature, have a medley of local terms, as "Country of Wady Salmá," "Lands of el-Wijh," and so forth, for the section bounded by the parallels of El-Muwaylah and Wady Hamz (N. Lat. 25° 55′) where the Egyptian and the Ottoman possessions meet. The southern moiety of the Khedív's province would thus measure in length 105 miles, a little less than the northern; whilst the depth inland must be at least doubled. The total extent of the Midianite seaboard then, is 213 miles, which the excessive sinuosities of the coast would prolong to 300.

I have taken the liberty of applying the venerable name "Midian" to all the littoral between El-'Akabah and El-Hejaz; and of distinguishing the upper half as "Madyan proper," or "North Midian," as opposed to "South Midian" the lower. In the by-gone days of Midianitish splendour and power, the frontiers were so elastic that they extended at times, as in the age of Moses, across the Gulf, and deep into the Sinaitic Peninsula. When Gideon judged, they stretched forth through Edom and Moab to the Esdraëlon plain. Their expansion and their contraction depended upon the relative strength of the tribes and clans, each acting upon the good old plan of taking and keeping all it could. My distribution is justified by ethnology. In the days of old, all the country was held by the Nabat or Nabathæans; in these times the people are, with one trivial exception, Egypto-Arabs. It is also politically correct. "North Midian" and "South Midian" still own the rule of H.H. Viceroy of Egypt: this prince garrisons all the seaboard forts that protect the pilgrim-highway from Suez to the sacred cities.

Dr. Aloys Sprenger, whose reputation as an artist is world-wide, offers two main objections to my thus extending the term "Midian." Firstly, it is an innovation. Granted—we cannot be Conservatives in geography and ethnology. Secondly, it prejudges the historic question concerning the relative claims of the rival Thamúdites and the Qodhâ'a or Kudá' tribes, who, in hoar antiquity, held the land. But this is going too far back; in the 19th century we need hardly be subjected to events preceding the 7th. On the whole it seems to me that by adopting the innovation we gain more than we lose. The question, however, must be left to that high tribunal—the Public Opinion of geographers.

As regards the proprietorship of our future mining province, I would remove every shadow of doubt. The *Times* correspondent from Alexandria (April 27, 1878) says, "that Midian lies to the east of the Red Sea, and that it belongs, for some mysterious reason, to Egypt, is all that 99 out of every 100 know about it." The mystery is easily cleared up. "Madyan Proper," or North Midian, was an Egyptian province in the days of the Pharaohs. The fort of El-Wijh still bears the name of Ahmed Ibn Taylún, founder of the Taylúnide dynasty in A.D. 868-84. The "Migdol" or castle of El-Akabah is yet inscribed with El-Ashraf Kansúh El-Ghori, the last but one of the Circassian Mamlúk kings of Egypt, who, in A.D. 1501, was defeated and slain by the Turks near Aleppo. Sultan Selim Khán el-Fátih, the conqueror, after putting to death the last of the dynasty, established Ottoman rule over all Egypt; and, consequently, over its dependency, the land of Midian. About 16 years later (A.D. 1517) he rebuilt the two forts and committed the charge and safeguard of the country to the Mamlúk Beys, the successors of the Circassian kings. The frontiers were defined by the simplest process; all was to be Egyptian in which the tribes paid tribute to, or acknowledged, the authority of Egypt; beyond them began the rule of Syria, the "impracticable and monstrous government" of the Porte, as it is called by General di Cesnola (p. 40). The reign of the Beys lasted till the French invasion (A.D. 1799); and was definitely ended by their massacre at Cairo in March 1, 1811. This event brought into power the great Mohammed Ali Pasha; he transmitted all his possessions and prerogatives to his descendants; and the latter, as you know, still rule all that has ever been called Egypt—and more. There is a greater Egypt, even as there is a greater Britain.

I must further trespass upon your patience by a short notice of the word "Midian." According to the Hebrews (Gen. xxv., 1) the land took its name from Medián or Medán, Abraham's fourth son by Keturah the Cushite, whom the "Friend of Allah" married after the death of Sarah (B.C. 1860). Median, the eponymus, became the sire of five patriarchs, who represent the progenitors of the extinct Midianites and their Pentarchy. Certain Hebraists declare that "Midian" signifies, in its own tongue, "strife, contention," a "litigious people," or a race struggling (for the possession of a country equally coveted by Asiatics and Africans). The word, however, occurs in many hieroglyphic texts; and the plural of Mádí would be Mádí-án, or Mádí-ná: we only know that in old Egyptian it is a barbarous and unmeaning term. According to the mediæval Arab geographers, whose testimony upon such remote events must not be accepted, "Madyan" is the name of the tribe to which El-Shu'ayb, the prophet Jethro, belonged. And I repeat, that "Midian" is a word confined to the writings of the Hebrews and the Arabs. The classics, as Strabo, Pliny, and Ptolemy, would include it under the comprehensive term Nabathæa,

whose western capital, Petra, has become familiar to you as Cornhill. Finally, "Midian," country, capital, and perhaps, chief port, ever bore, and still bears the same name, a practice common to this part of the East—witness "El Shám," (Syria and Damascus), and "El Misr" (Egypt, and Cairo).

The first glance which the voyager casts upon the land of Midian is a sight to be remembered in after years. That majestic scene, at once grand and simple, was right well suited to the heroic race of Bedawin who once held the soil. It reflects to a certain extent the Sinaitic Peninsula that faces its shores. Here, however, there is a sharper contrast of the flat and the high, the low and the tall, the horizontal and the perpendicular; of the well watered lowlands, with a luxuriant vegetation of emerald green, and of the rocky uplands, sterile and cruel as a moon-landscape; of the cloud-shadows flecking the mountains, and of the serene and lofty sky, so remarkable in these regions, that domes the plains.

Let us briefly note what we first see from the deck of our corvette. Beyond the cushions of golden sand which, hemmed and striped with verdure, oppose the bright blue waves, rise flat-topped banks and peaky hillocks of modern grit and arenaceous stone. Their dull yellows are almost hidden by sprinkles of dark silex, by weathered fragments of ruddy porphyritic traps, and here and there by blocks of pale, neutral-tinted, granite. Inland, these banks become foothills as gloomily metalled and revetted; but

> Across the dreary wild, the sun
> Casts umber'd radiance, red and dun;

whilst the picture is glazed with azure and purple by the intervening air of matchless purity and brilliance. The background is a towering line of kingly mountains, a surprise and a delight to the eye after the meanness and flatness of the Suez coast.

This sea-wall is known as the Jibál el-Tihámah, the "Mountains of the Lowlands," which correspond with the Ghâts of Western India: apparently continuous, it is broken into sundry blocks lying on different planes, and it reaches a maximum of 6,000 to 6,500 feet above the "water mirror." Amethyst-hued with aërial blue distances; here golden in the sun-glow, there bright with rose-leaf and flame-tint, and there again shaded with stripes of violet-brown and purpling red; barren and nude of vegetation, yet gorgeous in its coat of many colours, it stands fantastically cloven and sharply outlined against the bright ocean of cloudless air. Nothing can be more striking than these "Alps unclothed;" these monarchs of the Midianite mountains, which the prosaic old British navigator (Irwin, 1779) dubbed the "Bullock's Horns," and which a later writer (Wellsted, 1830) compared to "enormous icebergs." Their Titan shoulders, beaten by the suns and storms of ages, support peaks and pinnacles, organ-pipes, chimney-tops and Logan-stones; huge domes, truncated towers and sharply isolated cones. Fresh from the Dolomites of the Tyrol and Dalmatia, I had a first impression that the building material must be the same fire-bleached *calcaire*. Happily, it was a wrong impression, and, when anchored apparently at the base of El Shárr, the "Landmark," we remarked that the mighty curtain, which backs El-Muwaylah, seems to rise and fall as if by magic; it imitates in fact the framework of man. A giant during early morning, when the "dancing of the air" adds many a cubit to its stature, at midnight, after the equipoise of atmospheric currents, it becomes a dwarf *replica* of its former self. The cause is simply that which breaks the stick in water—refraction.

These mountains began north with the uplands of Moab, which rise some 4,000 feet above sea level; run down the whole western coast of Arabia; and meeting the eastern Ghâts, form a huge *nexus*, the Highlands of El-Yemen. Similar lateral fringes are constant features in triangular peninsulas, whose apex fronts the south: witness Africa, South America, Hindostan, Sinai, and little Istria. South of Moab they become the lofty right bank of the Wady el-'Arabah (of the 'Araboth or plains); in geological ages the upper bed of the Gulf el-'Akabah. The latter thus headed in the Dead Sea; and more than one engineer has proposed to restore the connection, threatening a 19th century deluge to the whole valley of the Jordan, including the Tiberias and Gennasereth lakes, which are 620 feet below sea level. The chain, single to the north, was known in the days of Rameses III. as "Sa'ar of the Shasu," the latter identified by the learned Brugsch-Bey with the Hyk-sos, or Shepherd Kings. The Hebrews term it "Mount Seir," meaning "the rugged," a name perpetuated in the Jebel Shará of the modern Arabs. Entering Midian at the Pilgrim-station El-'Akabah, the Elath of Solomon (B.C. 1000), it becomes a double range running parallel with the seaboard. There is, however, no distinct separation by plain or plateau; the only difference is that the granite predominates in the maritime ridge, the Jibál el-Tihámah; and the porphyrites in its eastern or inland neighbour. The latter line is called El-Shafah, corrupted to El Shifah, meaning "the lip," probably because it forms the margin or edge of the Nejd uplands.

The Ghâts are the salvation of Midian, their coast. The bare bastions of rugged rock at once act as barriers against the arid land-breezes, and condense the warm and moisture-laden winds from the Red Sea. The heavy downpours sinking into the loose sandy soils at their base, percolate underground, and presently re-appear in the shape of perennial pools at the shore-mouths of the Wadys or watercourses. Hence the dwarf-plots of grain and vegetables; the fruit trees and the luxuriant palm orchards, which look like torrents of verdure pouring down the land, are mostly confined to these places. During winter the highlands are reservoirs of "frigoric." Water freezes on the upper levels; and, swept by the raw and searching north-easter, the peaks have icy fangs, and the churlish chiding winds become Sarsars—cold and shuddering blasts. Despite their rigorous climate the higher regions of the interior are, I repeat, preferred by the Bedawin because the heavy dews and rains produce an abundance of pasture for their camels and asses, sheep and goats.

We will now take a bird's-eye view of the maritime line, beginning with the headwaters of the "Red Sea of Edom" (1 Kings, ix., 26) and ending at the frontier of the Moslem' Holy Land. "Madyan Proper," or North Midian, opens with the sandy and stony lowlands of the 'Akabah Gulf,

cut by a network of dry torrent beds, and gradually upsloping to the single range of eastern mountains. The coast is dangerous in the extreme; the lead often falls 120 fathoms without striking bottom; both the north and south winds are a terror to navigators; and the fine ports mentioned by Procopius, are little coves barred and blocked with coralline reefs. About midway the Ghâts impinge upon the shore; they then sheer off inland, and their place is taken by foothills rising from a slip of coast. About Makná, two-thirds down the 'Akabah Gulf, the eye is pained by a secondary formation of gypsum, which contrasts strangely with the blue mountains, and the bluer seas. Now tinged with a sickly yellow or greenish hue, then a ghastly glaring white, and everywhere bare as a bone, it is the bleached skeleton of a grisly land. The formation which extends in a broken sheet to the Sinaitic peninsula opposite, and which may be traced down coast to our extreme limit, is evidently older than the Gulf. It is ribbed by ridges of felsite and porphyritic trap, dark-red and bottle green, usually trending north-south, a black-stone land in a white stone land, and looking from afar like gloomy reefs in a milky sea.

The name, Makná, is the same in Ptolemy (vi. 7) who writes it also Maína and Maéna. Josephus terms it the village Midian, and the mediæval Arab geographers describe it as the "ruined town Madyan, containing the well where Moses watered the flocks of El-Shu'ayb" (Jethro). It is still known to the Arabs as "Madyan," the name of the country; and it has evidently borrowed it from the capital, Madiáma, or Magháir Shu'ayb. Here we found vestiges of an artificial harbour, a high town, which may have been a monastery, and the "Praying place of Moses," a ruined building of alabaster, but no well.

The *báb*, or "gate," of the 'Akabah Gulf is formed by a series of long low projecting points, named by the charts Ras Fartak, "the headland which powders or beats to pieces." It is known to the Bedawin as Ras Sheykh Hamíd, and pious visitation is still made to the tomb of its holy man. Here, after a total length of 90 miles (N. Lat. 29° 30' to 28°), ends the 'Akabah Gulf, whose unbroken eastern shore-line runs from NN.E. to SS.W. Beyond this point, the Midian coast suddenly sweeps from west to east for an extent of 40 miles. It is torn and broken by the violence of the southerly gales into a fringe of thin sand-tongues, often sickle-shaped; and it is outlaid by a small archipelago of *îles brisées*, reefs, and shoals. The chief islets, ranged upon a parallel of latitude, number four, Tírán (of birds), Sinafir (possibly after Pharaoh Senoferu), Shu'shu', and Barahkan; with Yubú' and Silah to the south. They were evidently known to the ancients; and every modern geographer has the pleasure of identifying for himself Iotábe and Dia, Salydó, Soukubuá, and Isis Islands.

I cannot but hold this great bend to be the *Kolpos* (gulf) of which Diodorus thus speaks. "The navigator, passing the grassy plains (to the north where little grass now grows), is received by a bay, a paradox of nature, which trends inland to the innermost recess, a depth of 500 stadia (50 geographical miles), enclosed everywhere by rocks of marvellous size. The mouth is crooked and hard to hit, for a low reef hems in the bay allowing neither ingress nor egress. Amidst the rush of the current and the shiftings of the wind the billows boil tremendously, and are ever breaking upon the stony shores that oppose them. The people, called Banizoménes, live upon the flesh of wild beasts hunted by dogs. At that place is a most holy fane held in highest honour by all the Arabs."

It is impossible not to suspect that these fantastic, imaginary, sensational horrors were fabled by the Midianites to deter strangers from interfering with their monopoly—metal-working. Rüppell, the landsman, repeats that 'Aynúnah Bay, the "innermost recess," is "full of shallows, and quite useless for shipping." Wellsted, the sailor, describes it as well sheltered from all winds; and assures us that "under a good pilot a vessel might enter with every facility and safety." According to Agatharkides, Diodorus, and Photius, the "tailings," or gold sands, began to the south, in the land of the Debai (Debæ, Thebæ, or Dahabán—N. Lat. 21"); while the Alilaioi (Alilæi of Hali, N. lat. 18° 15') were rich in nuggets. "They find," say our authorities, "a quantity of gold in the crusty substrata" (the *Cascalho* of the Brazil), "not dust, melted and treated with technological skill, but produced by nature and called by the Greeks *Apyron*." The word, meaning metal not requiring purification by fire, is synonymous with the Arab *Tibr*, or nugget gold, purer than stream ore. They continue, "The smallest pieces are not smaller than an olive-stone, those of medium size equal a medlar, and the biggest a walnut. The people wear nuggets round their wrists, threaded alternately with transparent stones, and sell them cheaply to their neighbours. Brass (copper? zinc?), is worth twice, iron double, and silver ten times their weight in gold." And yet there are moderns, Niebuhr for instance, who declare that "the precious metals are not found or known to exist in Arabia, which has no mines either of gold or silver."

Let me finish the bird's-eye view of the maritime Midian. South of El-Muwaylah, the face of the country preserves its peculiar physiognomy with slight alterations of feature. The mountains decline in height from a maximum of 6,500 feet to 3,300. The volcanic chain approaches the shore; fewer and smaller islands break the coast-line. The seaboard-plain waxes broader and more important; the temporary "tabernacles" of the Bedawin, mere shanties or booths, became villages of masonry; and the southernmost, El-Wijh, claims rank as an Arab town. Finally, with these characteristics ever more forcibly displayed, we reach the great Wady Hamz, the frontier of Egypt and the Ottoman Hejaz.

Midian is not included by Hebrew Holy Writ in auriferous Arabia; and the rich booty of precious metals which fell to Moses and to Gideon might have been made by merchandise as well as by mining. The chief diggings (Gen. x. 28-29) were Sheba, Ophir, and Havilah, all in the southern peninsula; while the centres of minor importance were Hazeroth, Parvaim, and Uphaz. Hazeroth is mentioned in the Exodus (Deut. i. 1); where the A. V. reads "Hazeroth and Dizahab," instead of "Hazeroth, where there is gold;" or "which owns gold." This Hazeroth is usually identified with the modern Ayn el-Hazrah, a fair valley near the

N.E. coast of the Sinaitic peninsular, a little north of the Wady and Marsá Dahab, the "water-course and anchorage of gold." Parvaim is the modern Farwah in Khaulán which represents the land of Havilah; and Uphaz may be a simple corruption of Ophir.

After this general *mise en scène*, I proceed to the actualities of our travel in Midian. Let me mention, by way of preliminary, that both of the expeditions, which I had the honour to lead, were sent out at the sole expense of H.H. the Khedív of Egypt, Ismael 1st, a Prince to whom the future will be more generous than the past has been just. To this Viceroy alone we are indebted for our present knowledge of the neglected and almost mythical old "kingdom." Dr. Edward Rüppell, the first explorer in 1826, was compelled by slender means to make a flying trip through a land inhabited by tribes who were never safe, and who, at times, were dangerous. Wellsted, when surveying, under Moresby, the coast of Midian, in 1835, shows that more than once he and his men ran risks from wreckers; and had to face the chance, when they landed, of being held to ransom. The late Dr. George Augustus Wallin, in 1847, could only make a flitting across the country, and was unable to visit the most interesting sites.

The energetic Viceroy changed all that. During the spring of 1874 His Highness forwarded, in his little steamer *Erin*, my regretted friend, Dr. Charles Beke, who, at the ripe age of 74, gallantly went forth to find the "True Mount Sinai." You are doubtless familiar with the splendid volume, "Sinai in Arabia" (Trübner, 1878), so ably and fondly edited by his widow, Mrs. Emily Beke. In early 1877 the Khedív was pleased to place under my command the first Khedivial expedition; it consisted of a small guard of Egyptian officers and men, with a French engineer, M. George Marie, and an Englishman, Mr. Charles Clarke, acting commissariat officer and accountant. This preliminary visit lasted little more than a fortnight (April 1-18), but it gave me a fair general view of the country; it brought back specimens of gold, silver, and, in fact, all the metals mentioned in the Book of Numbers; and it enabled me to publish my prefatory volume, "The Gold Mines of Midian."

Invited, in 1878, to carry out the discoveries of the previous year, I returned to Cairo, and organised, under the auspices of His Highness a second Khedivial expedition. This time it was mounted upon a larger scale. Besides my two former *compagnons de voyage*, an artist, M. Lacaze, and a smith, M. Philipin, were engaged. Six Egyptian officers, including two upon the staff, commanded an escort of twenty-five Negro soldiers, carrying Remingtons, and a gang of thirty unarmed miners, or rather quarrymen. We were liberally supplied with mules, tents, and rations for four months; and we had an abundance of rude implements, picks, crowbars, and boring rods. As the first exploration had been purely tentative, so the second was expected to bring back, in masses sufficient for assay and analysis, quantitative and qualitative, and specimens of all the formations that appeared metalliferous.

After the delays and troubles inherent in such undertakings, the Expedition embarked on board the despatch-boat *Mukhbír;* and, after duly breaking down, landed at El-Muwaylah, on December 19th, 1877. As will be seen, the *reconnaissance* of the country naturally distributed itself into three distinct sections; 1, through North Midian; 2, through Central or Eastern Midian, that is, into the interior; and 3, through South Midian. The three occupied four months within a single day.

I had great hopes for our first or northern excursion, which lasted 54 days, till February 13th, 1878. My old friend, Haji Wali, who, about a quarter of a century ago, had showed me gold dust in "tailings," accompanied us, and I had no reason to suspect his honesty. Nothing could be more disorderly or distracting than the caravan when first formed. The men, even wilder than their half-wild animals, began work at 3 a.m. and ended about 8 a.m.; while the fractious, peevish, fretful, grumbling "desert ships" numbered 106 instead of 80. However, under Dar-For discipline, matters presently improved; the beasts diminished to 64, and loading-time to a quarter of an hour.

We marched at first northwards along the seaboard which lies at the base of its great range. It is known familiarly as El-Sáhil ("the shore"), geographically as the Tihámat Madyan. The "Lowlands of Midian" are thus distinguished from other sections of similar formation; Tihámat meaning the hot, unhealthy coast-plain, opposed to El-Nejd, the salubrious uplands. The breadth would vary from *nil* to 28 direct gross miles. The "null" is about midway, where the block El-Mazhafah falls sheer into the Gulf El-'Akabah; and the maximum breadth would be between 'Aynúnah and the semicircle of mountains forming the background. This Tihámah is evidently in part a modern growth; the shore-line is a false coast built of *débris* washed down from the Ghâts; while further inland rise the foot-hills of the Jibál, the main range. The surface is disposed in alternate stripes of sand and stone. The former are the Wadys, or water-courses, the Hebrew *nachal*, the Anglo-Indian *nullah*, the Greek *kheimarrhoi*, the Italian *fiumare* and *burroni*, and the *potoks* of the Slavs. Not having the thing, we hopelessly English the word by "dry river," by "winter brook" or "torrent;" or, worse still, by "valley." Where breaking through the mountain flanks, and deeply encased by cliffs and slopes, the beds roll, every ten years or so, devastating torrents like those of disforested France. Nearer the sea they flare out into open undulating plains of soft sand, which, all trending to the south-west, occupy at least half the ground. Here they are divided from one another, not by distinct lines of hills, but by a wave of land, mostly arenaceous matter metalled with a natural macadam of dark silex, trap, and iron-stained grits. Vegetation—salsolæ, acacias, and mimosas—is here rare, and water is rarer, save close to the sea. Consequently, the rainless and sun-parched Tihámah is shunned by the Bedawin, who feed their flocks and herds upon the hills, descending only during the date harvest, July and August. In the uplands they affect the tent; in the lowlands the "tabernacle," or hut, built of grass, reeds, and the trunks and fronds of the palm, and looking from afar not unlike ragged bird's nests.

Our route led, *viâ* Wady Tiryam and Sharmá, to the Jebel el-Abyaz, or White Mountain, meaning, "of quartz." After a week's work on and around

it, we returned to Sharmá, and marched upon 'Aynúnah. Of these places I shall say nothing, have they not all been written in my published volume? We then broke new ground from 'Aynúnah to Maghâir Shu'ayb, the "Caves of Jethro." It corresponds with "Madiáma," the "Mesogeian city" of Ptolemy (N. Lat. 28° 15') and must not be confounded with his Modíana, or Modoúna (N. Lat. 27° 45') whose position (Sharmá? Tiryam?) is still under the judge.

These ruins show what was, after Petra, the largest Nabathæan station on the great highway, one of the earliest of our many "overlands," which began at Leukê Kóme, the southernmost port, and which followed the eastern coast of the Red Sea, in order to avoid the dangers of the 'Akabah Gulf. From its northern terminus, the "City of the Rock," roads branched off to Syria, Egypt, and the Mediterranean; and thus the cloths and ivories, the spices and perfumes of India found their way to the outer world. The remains are most interesting, despite their maltreatment by time and man. My coming book "The Land of Midian (revisited)," will enlarge upon the picturesque high-town and palace (Laura?) crowning the gypseous hill which overlooks the bank; the broken alabaster walls, forts and houses of the "Mutakaddimin," *veteres*, or old ones; the Nabathæan catacombs dug in the solid rock, and the huge tank and guard-house of the mediæval Moslems. Here, and here only, we found some 250 Midianite coins; besides which we brought back specimens of stone weapons, and articles of steatite like those of the Brazil; copies of *graffiti*, and fragments of bronze, which will be compared by assay with the metal of the European prehistoric age.

From Madiáma, whose ancient civilisation was apparently that of the Nejeb, or South Country mentioned by Abraham, we marched down a remarkable valley to Makná, its sea-port. The little cove, at the northern extremity of the gypsum-field, has been minutely described by the late Dr. Beke and myself (p. 14, 15.)

At Makná the aviso *Mukhbir* awaited us, and after a severe storm that blew away our heavy tents like umbrellas, we embarked for the other side of the 'Akabah Gulf. How we rounded that restless and perilous water; discovered the metal-diggings of ancient Elath, now Akabat-Aylah, and escaped shipwreck only by the energy and courage of Mr. David Duguid, our Scotch engineer; and, finally, how we returned to El-Muwaylah safe and sound, by a manner of miracle, will presently be told to the world in detail.

The first Khedivial expedition had brought back, from this fine mining country, specimens of free gold, found in basalt apparently eruptive; silver appeared in the red sands, and in the pavonine quartz, and titaniferous iron of the Jebel el-Abyaz; silicate, carbonate and other forms of copper were extracted from chloritic slate and quartz; lead and iron lay everywhere; zinc was abundant; half the land was composed of gypsum and selenite, and the sulphur rivalled that of Naples. The second visit added to these metals a quantity of antimony and, I suspect, of mercury.

After a short rest for man and beast at El-Muwaylah, I organised the second excursion through Central Midian. The object was to determine the depth of the metalliferous region from west to east; and, in the latter direction, I had hopes of finding a virgin goldfield. We set out on February 19th, and travelled 18 days, not including a week devoted to exploring the mighty Shârr *massif*, behind El-Muwaylah.

A devious march of five very short stages led us through the double parallel line, known as the Jibâl el Tihâmah and the Shafah. The expedition then reached the region called El-Hismá, a word primarily meaning a desert-flat, with dusty hillocks. It is a long, thin line of the New Red Sandstone; a hollow plain, measuring about 170 miles from north to south, and varying in height from 3,000 to 3,800 feet. The loose, siliceous soil, here pink, there pink-white, dotted with isolated cones, is fair to look upon; and wants only water to become exceptionally fertile. In the south it is prolonged by El-Jaww, "the hollow," a region as yet unvisited by Europeans. Eastward, the Hismá abuts upon El-Harrah, the "hot" or the "burnt" region, a volcanic tract, to which inadequate limits have been assigned. Wallin, who traversed it in 1848, makes it a parallelogram, about one degree long (N. Latitude 28°—27°), and disposes it diagonally from north-west to south-east. Thus, it heads a little north of El-Muwaylah, where it lies some 60 miles from the sea; and it tails near El-Jaww. I found, however, by inquiry from the Arabs, that this eruptive region is much more extensive and important than our maps allow. It begins to the south-east of the Dead Sea (N. Lat. 31°); about 150 miles south (N. Lat. 28° 30'), we found an off-set near Makná; we first sighted it, on this excursion, east of the parallel of El-Muwaylah (N. Lat. 27° 40'), with a little northing, and we last saw it near El-Haurá (N. Lat. 25° 6'). Moreover all assured us that it reaches the neighbourhood of Medina and El-Yambiú', some 60 miles further south (N. Lat. 24° 6'). If these limits be true, the line of vulcanism subtending the north-western flank of Arabia would measure from north to south nearly 7°, or, more exactly, 414 direct geographical miles.

These two regions, the Hismá and the Harrah, may be defined geographically as the western walls of El-Nejd, the great plateau forming the heart of Arabia, the home of the Arab blood horse; and the centre of all that is brave and beautiful, and thoroughbred in the races of Arabian man and beast. This section of our march gave us a correct profile of the five formations which lie parallel and east of one another. They are—1, the sandy and stony maritime region, the foothills of the Ghâts, granites, porphyries and traps with large veins and outcrops of quartz, and Wadys cutting through thick beds of conglomerates; 2, the Jibâl El-Tihâmah, the majestic range which bounds the seaboard inland, composed of granites emerging from the felsites and porphyritic traps; its broad sandy beds, rivers without water, and narrow rock-gorges form the only roads; 3, the Shafah, or lip, a prolongation of the Ghât, in which the porphyries almost obliterate the granites; 4, the Hismá, or strip of New Red Sandstone; and 5, the Harrah, or volcanic region.

Our march eastward, and its benevolent mineralogical intentions were violently arrested and frustrated by a bandit tribe, subject to the rule, or rather the no-rule, of unfortunate Syria. These

Ma'ázah, with their kinsmen, the Beni Atíyyah, have extended as far north as Moab, where their razzias are much feared. Modest demands of 100 dols. (£20) per diem, and symptoms of reviving the terrible *vendetta*, the blood-feud, began in the evening when we crossed their frontier. We had come, not for war, but for exploration. We were hardly strong enough to fight; and, had we fought, we should have been in the wrong. The tribe was ungentle and inhospitable, greedy and turbulent: still, according to Arab ideas, it had the fullest right of dictating the terms under which it would permit foreigners to pass its frontiers. Lastly, our Shayks of the Huwaytát tribe had freely trusted their lives, their men, and their camels to my guidance; and I was bound to see them safe out of the lion's den.

Yet not the less was February 25th a veritable ember-day. We retraced our footsteps, and decended the double *Khuraytah*, or "pass," which connects the Hismá with the Tihámah. Free from the Ma'ázah we now bent to the south and the south-east, over what I believe to be untrodden ground. We explored and collected geographical details concerning the three great parallel basins, especially the Wady Dámah; this is a species of Arabian Arcadia, where clumps of trees form important features in strangely picturesque views, worthy of Petra and Moab. We also dug into and planned the two principal ruined cities, called by the Bedawin, "Shaghab and Shuwák." The latter lies in a broad water-course, upon a long bank of modern sandstone and clay, which a sandy branch, on either side, converts into a manner of holm, or riverine islet. The town preserves only bare foundations of masonry, and little salt-white heaps, which mimic the mighty tumuli of Babylon, Nineveh, and Troy. We traced a fort, a tower, a number of smelting furnaces, and caves which have been catacombs. The arrangements for collecting and distributing water have been upon a large scale—tanks and cisterns, leats and conduits, chanelled with rough cement overlying a firmer concrete. The *magnum opus* is the great aqueduct on the left bank, showing, where the sands have not buried it, a length of at least 1,000 metres, and ending in a reservoir which measures 48 paces each way. This Shuwák was evidently, like Madiáma, a station on the great Nabathæan "Overland;" and, subsequently, on the highway of the Pilgrimage-Caravan before the 16th Century, when the maritime road was laid out. It astonished us by the traces of immense labour, without yielding a line of inscription or even a mason's mark to clear up the question of its inhabitants. We determined it to be a huge *Warshah*, or workshop, and a settlement of miners. Shaghab, its neighbour, separated by a dwarf divide, and distant about seven miles to the southward, appears to have been the abode of the richer classes; we found there a better style of building, with glass and other *objets de luxe*. I came to the conclusion that the two combined to form the *Σόαμα* which Ptolemy (vi. 7) places in N. Lat. 36° 15′, or about 1° (= 60 miles) too low.

From these poor remnants of past labour, and of industry now forgotten, we made our way to the shore at Zibá, passing the two less important ruins, El Khandaki and Umm Amil. The latter was noteworthy because it supplied us with the finest specimens of smelted copper. The harbour village is probably the Phœnicon Vicus of Ptolemy (N. Lat. 36° 20′); and behind the modern settlement there are signs of an older town buried in the sands. From Zibá we proceeded to the mountain and watercourse El-Ghál, lying a little inland of the pilgrimage-route, which here hugs the sea-coast. The gloomy block has yielded fine turquoises—or, rather, johnite—which, at Suez and Cairo, pass for Siniatic. The matrix is chocolate-coloured quartzose rock; and, in addition to the *Lapis pharanitis* of Pliny, the *Gemma turcica* of our Middle Ages, which gave the gem its modern name, one specimen contained silver. The Zibá diggings, ignored by the Egyptian Government, are well known to sundry adventurers. An Italian lately brought away turquoises worth considerable sums; and, to judge from a specimen set in a Bedawi's gunstock, they are not liable to change colour like the *mafka*, which the old Egyptians worked in Sinai. These men have also taught the Arabs the latest "dodge" in pearl-culture—inserting a grain of sand into the shell of the live oyster. On March 8th, we returned to El-Muwaylah, passing by the middle Jebel el-Kibrít, or "Sulphur hill," where M. Philipin had been working with a will. This second excursion brought back two bags of the true turquoise-matrix, with visible silver; worked slag, or obsidian, containing free copper; specimens of smelted copper and sulphur; and rock-salt from the Jebel el-Kibrít, which had been visited by the first Expedition.

No. 2 march ended with an ascent of the Shárr, properly El-Ishárah, "the landmark," the glorious "Hippos Mons" of Ptolemy, which backs El-Muwayláh. This trip gave us a good study of the Gháts of Midian, with their noble crests and walls of snowy quartz; their quaint chimney-tops, pins and pinnacles, domes, and parrot-beaks of colourless granite; and with the vast sheets of hard red felsite, and soft porphyritic trap, green and bottle-green, swathing them from the middle to the feet. The Sharr is very badly laid down in the hydrographic Charts, which ignore the names of the several peaks; and which, moreoever, assign to the rock 9,000 instead of 6,000—6,500 feet above sea level. The main peculiarity is that the vegetation, instead of dwindling and diminishing with increase of height, as is the usual rule, gains both in quantity and quality. Near the summit it becomes distinctly Syrian; and we were pleased once more to meet the strong-smelling ferula, the homely hawthorn (*Cratœgus*) and the juniper tree, with trunk thick as a man's body. Of this Scriptural "heath" (Jer. xvii. 6) we brought back branches and berries; and the latter, I hope, may be induced to find a home in England and Ireland.

Returning once more from the mountains to El-Muwaylah, we were delighted to find our old friend, the corvette *Sinnár*, which H.H. the Khedív had thoughtfully and courteously despatched to take the place of a "tin kettle" so uncommonly likely to drown herself as the *Aviso Mukhbir*. After a delay of two days, in order to sort out the party, and leave the sick at the fort, we began our exploration of South Midian, the third, the last, and the most interesting of our three journeys. Had I known what we do now, we should have opened at the south, and have devoted to it the greater part of our four months.

The first day's cruise ended at the noble port El-Dumayghah; which, situated only 30 miles north of El-Wijh, is so admirably fitted as a harbour of refuge for pilgrim-ships. It has been neglected by the charts, but the Egyptian staff officers carefully surveyed it. On March 24th we anchored in the dangerous cove of El-Wijh, the northernmost town on this part of the Arabian coast. It has greatly improved since my first visit in 1853, the reasons being increased traffic with the Bedawin, and the establishment of a well organised quarantine-station, with mole and lighthouse, barracks and bakeries. Unfortunately, about two years ago, the place of penance was moved northward to Tor, in the Sinaitic peninsula, where it has become a standing menace, threatening cholera, small-pox, and typhus, not only to the Nile valley, but to general Europe. I hope that the English and Egyptian governments will see the advisability of at once re-transferring the quarantine station to El-Wijh.

Here the expedition separated; MM. Marie and Philipin were directed to inspect a third sulphur-hill, distant some 25 miles down coast. They were completely successful; and they brought back, moreover, accounts of a classical ruin which appeared worth visiting. Meanwhile, accompanied by the other division, I proceeded southwards in the *Sinnár*; and, after covering some 70 miles (dir. geog.) we came upon the ruins of El-Haurá, in N. lat. 25° 6′. Here, doubtless, lay the celebrated emporium, first Nabathæan, then Roman, or rather Byzantine, Leukè Kóme, the "White Village"—Whitby. After surveying its land and water, despite the turbulent Juhaynah, we returned to El-Wijh, and found that the 58 camels wanted for carriage had been collected by the venerable Shaykh Afnán, chief of the Baliyy. This tribe, unlike the Huwaytát, is of ancient and noble blood, supposed to be Joctanite, as opposed to Ishmaelite; it emigrated from the south before the days of Mohammed, and seized the lands of the Beni Tamúd or Thamudites, then the allies and auxiliaries of Rome. The Baliyy retain a flavour of old civilisation; and still show the mining instinct: this evident result of atavism will prove most useful when the old diggings shall be worked anew.

Leaving El-Wijh on March 29th, we attacked the interesting interior. The ruins called "Umm el-Karáyát," and "Umm el-Haráb," showed us, for the first time, scientific workmanship, shafts and galleries sunk and pierced in the solid rock; the object was to reach the white quartz, which veins the gray and other granites. After six short, slow marches, inspecting and surveying, mapping and planning, we debouched upon the fine mountain-girt plain of Badá, whose abundant waters and dense palm-orchards are celebrated far and wide. The Greek Badaïs, and the Roman Badanatha (Pliny. vi., 32), which Ptolemy (vi., 7), places in the Lat. 25° 30′ (instead of 26° 45′), it was the very heart and centre of Thamuditis. I may safely predict that it will still see better days.

From Badá we bent southwards,

And now the hills stretch home.

After visiting the quartz-field called "El-Marwát," we were compelled to take precautions; this frontier-country is swept by razzias of the Anezah to the east and the Juhaynah to the south. Marching *militairement* is no pleasure when your camels, faint and feeble with hunger, can hardly cover 2½ miles in the hour. Thus creeping, we travelled down a succession of broad watercourses, showing glorious rocky scenery in the "Mountains of the lowlands of the Baliyy." The land may be described as one vast outcrop of quartz, which bars the Wadys, and rises in conical heads several hundred feet high. On April 8th, we reached the great Wady Hamz, which, I have said, separates the southern limit of South Midian from the northern frontier of the Hejaz. It is by far the most important feature of the kind in North-Western Arabia, the highway of caravans leading some fifteen marches into the interior, and the site of the ruined Nabathæan city, Madáin Sálih. Of course it is unknown to the Hydrographic Charts; Wallin, copied by the mappers generally, miscalls it Wady Nejd, and even the erudite Sprenger ignores it. The head, according to the Bedawin, is near Medina, and the mouth is in North Lat. 25° 55′. This and the enlarged limits of the Harrah were *the* geographical discoveries of the journey.

Upon the southern bank of the Wady Hamz, and facing the Ghat scenery to the east, lie the ruins of a shrine known as Kasr Gurayyim Sa'id, the "Palace of Sa'id the Brave." It is a startling contrast with its wild surroundings, this highly civilised *maison carrée*, a cube of white and mottled alabaster, measuring 8.30 metres each way. Mr. James Fergusson, whose authority in such matters few will question, compares it with the fane at Suwaydah in the Haurán, planned and described by M. de Vogüé (Pl. iv.). If so, it is late Roman, and dates from the days of Herod Augustus. Sa'id the Brave was a huge negro chattel, who carried off his master's daughter, built this "palace," and ate a camel for dinner, till the country-side, scandalised by the exuberance of his meat-diet, rose up and slew him.

From the Shrine we bent a little eastward of the direct route trending north to El-Wijh; and visited the immense quartz-field, known as Abá'l-Marú. Our *détour* was rewarded by the discovery of sundry ruins, and a wall-like reef of the white stone, some 200 feet high and at least half a kilomètre long. The rocks, too, were profusely veined with the variety of quartz called chalcedony, an agate used for seals; its fragments showed dendritic gold. I have no doubt that this is the mine "El-Marwah" or "Zú'l-Marwah," mentioned by so many of the mediæval Arab geographers. *Marú*, both in the classical and vulgar tongue, means "quartz;" and we have found it applied, under various modifications, to sundry features in Midian, especially in the parts adjacent to the Wady Hamz. I am disposed to translate Ophir by red-land; and to hold it, like Sheba and Havilah, a district, not a settlement; you must remember, however, that every traveller in Arabia has his own "Ophir." Marwah, for instance, in the hillock of Mecca, certainly signifies a single place of quartz; Marwát would be its plural; and, finally, Abú'l-Marú is the "Father of quartz," in other words, a place were quartz abounds.

On April 10th we ended our third excursion by returning to El Wijh. During the last 24 days we had inspected and mapped a linear length of 170 miles. This South Midian differs essentially

from the northern moiety. Whilst the latter extracted its argentiferous and cupriferous ores; the former worked for gold and silver. Moreover, though the section of the province near Egypt preserves few traces of the miner, here we find extensive remains where he has treated the rock carefully and scientifically. The whole western counter-slope of the lowland chain belonging to the Baliyy is one vast quartz-field, and, as might be expected, not one tithe of it has been touched. We brought back from the Badá plain specimens of spalled stone, each bit showing its little mass of pure lead—a rare metal. Gold was seen in the chalcedony-quartz and in the junction of rosy schiste veins with the quartz walls. Saltpetre is everywhere, and I have noticed the third or southern sulphur hill.

The second Khedivial Expedition, which disembarked in Arabia on December 19th, 1877, had now ended the work proposed to it. On April 18th the *Sinnár* corvette left the coast of Midian, carrying the men and mules which she had landed. There was only one death, a quarryman, who succumbed to ague and fever. The journey had covered, by sea and land, nearly 2,500 miles, of which some 600 were mapped by Lieutenants Amir and Taufik, of H.H.'s staff; and a few crucial stations were astronomically fixed by the Egyptian naval officer, Ahmad Kaptán. It had measured, and planned, and sketched the skeletons of 16 settlements, large enough to be called cities, still showing remains of extensive public works. Moreover, it had seen or heard of nearly thrice that number of villages and "ateliers." M. Lacaze stocked his portfolio with at least 200 *croquis*, oil-colours, water-colours, pencil drawings, and photographs. Besides the 25 tons of rich specimens collected for assay and analysis, we brought back to Cairo a small ethnological "find" of stone implements, rude and worked; the coins of ancient Midian mixed with Roman and Kufic; fragments of copper and bronze, glass and pottery; Nabathæan inscriptions and Arab tribe-marks; a box full of skulls; spirit specimens of zoology; shells from the shores of the Red Sea; and a *Hortus siccus*, whose interesting part consists of Alpine plants gathered at an altitude of 5,000 feet. Finally, Mr. Clarke, acting as commissariat officer, was diligent in keeping accounts, and assisted me in filling the meteorological journal.

Such, in the last quarter of the 19th century A.D., is the condition of the venerable country, whose name is for ever connected with Joseph and his brethren, with Moses and Jethro, with the wanderings of the Hebrews, with Gideon and Balaam, and with the heroic Bedawin, Zebah and munna. It is evidently far less civilised than it was in the 19th century B.C.

You now know as much about Midian as I do: instead of being a vision, a mystery, it has become to you a thing of reality. You will join me in lamenting the contrast between what it has been and what it is. Pathetic, indeed, is the view of its desolation; once the flower of Arabia Felix it has become a Petræa, a Desert. The incubus of destruction has sat for years upon its glorious mountains and luxuriant water-basins; the wild man, the father, not the son, of the wilderness, has done and is still doing his worst. Similarly, when the Romans ruled Africa Propria, and Numidia, the regency of Tripolis numbered some twenty million souls; the population, then as thick as that of Belgium, is now reduced to two millions.

But the Anglo-Turkish Convention places Great Britain with reference to Arabia nearly in the same position as that occupied by Rome after the days of Augustus. I have a full and perfect faith that Midian, like many another province, will presently awake from her long trance, from her sleep of ages. She offers to the world, not a mine but a mining region, some 300 miles long, with an inner depth as yet unknown; and what the ancients worked so well we moderns can work still better. Let us look forward to the development of her mineral wealth under the fostering care of European, and especially English, companies. So we may expect to see the howling wilderness, like Algeria before 1830, rival the rich and fruitful province of Algiers in 1878.

Meanwhile, I have only to thank you for the patience and perseverance with which you have listened to my long story, and to bespeak your interest for the future welfare of the grand old "Land of Midian."

DISCUSSION.

The Chairman remarked that they had listened to a very graphic and exceedingly modest address, in which they had had scarcely a single description of the fatigue and hardships which Captain Burton had undergone. He himself was only a sort of feather-bed traveller, but, having been some little abroad, in Asia Minor and the Arctic regions, he could appreciate what one had to go through who undertook such a journey as had been detailed. Language would almost fail to describe what travellers had to suffer in those regions. The scorching sun of the day and the chilling temperature of the night, the hard fare they had to live upon, and the patience they had to exercise in contending with the rude people about them, was something most appalling. They had heard that night a man who had, perhaps, seen more of dangerous travel than any other man living, or, at all events, ranked amongst that select few who had opened up new and unknown countries to us—lands where the poetic vision could barely penetrate, and see what their future might be. Their thanks were due a thousandfold to all such men; for though they knew something of what they had endured, they could not say what might come. He could only thank Captain Burton personally for his great kindness in coming there to read such a paper; and he hoped they might have some interesting remarks upon it. Perhaps Prof. Tennant would have something to say on the geological part of the subject.

Professor Tennant said he was not prepared to say anything, there being no specimens which he could examine. He knew something of a gentleman (Mr. Milne) who had gone over a portion of the ground in company with Dr. Beke, and he had seen some of the specimens he had brought home. One or two of the statements made rather startled him, as, for instance, that pure lead had been found. He should like to know if it was really pure lead or an ore?

Captain Burton said it was pronounced by Captain Rose to be pure lead.

Mr. Lee Thomas asked if Professor Tennant had ever seen pure native lead?

Prof. Tennant said he had not, except under peculiar circumstances, where its existence could be accounted for. It had been found in volcanoes when the sulphur

had driven off from the ore, and the lead run down, but never in a mineral vein.

Mr. John Haddan, C.E., said he had the honour of seeing Captain Burton and his noble wife in their war-paint, ready to start. The Chairman had, in very feeble language, described the sufferings which Captain Burton had never mentioned himself, or paid any attention to; but he had seen him about two months ago, just after his return, and a more toil-worn individual he never saw. He wished to point out that the value of Captain Burton's travels was not to be measured by the number of dangers endured, but by the after-good they might do. As a man who had been many years among the Arabs, he might say that the good reputation we had among them was more due to the way in which Captain Burton went about than to anything else. It was not proper there to go into politics, but Englishmen had suffered in the East from the "masterly inactivity" of the late Government, and it would have gone still further, if men like the gallant Captain had not held their own in spite of the Government or anything else. He knew Captain Burton tolerably intimately, and what has been his reward? Nobody answered! No reply; nothing. He knew men who had been made C.B.'s and K.C.B.'s, he knew not what for—next to nothing. Here was the gallant captain without such an honour. He did not know whether he would accept it now, but, at any rate, he should like to see the offer made.

A Member asked if Captain Burton had visited the Petrea, which was described some years ago by an American traveller, named Stevens?

Captain Burton said that the place was very well known, and many ladies visited it every year. His object had been to explore countries unknown.

Mr. Basil Cooper said the two or three words Captain Burton had dropped respecting Egypt, seemed in some way to connect the new and the old with regard to this subject. This expedition, like the former under Captain Burton, was sent forth by the Khedive, and he trusted that what the Captain had said respecting the debt of gratitude which future ages would pay to the Khedive would be realised. His pecuniary affairs had been somewhat gloomy, and his relations in that respect with this country had not been of the brightest kind, so that in that way things might have tended to somewhat cloud his character, but he was certainly a ruler of great enterprise and energy. His connection with this country pointed to the past of Midian; the very name seemed to turn up earliest in Egyptian hieroglyphical inscriptions, for it was certainly there, whether or not it referred to the land and people now described, as to which he would not express an opinion, though he thought there might be something in the notion. Those Madai mentioned in the Egyptian inscriptions, so far as any plausible conjecture could be formed, seemed to have come from the eastern extremity of the Black Sea, and they were mercenary troops in Pharaoh's army from the very earliest times, even under the earliest dynasties, they were found named as such; and about the time of Rameses III., they were replaced by another race of household troops called the Masshuwatta, who were certainly the Maxes which Herodotus spoke of in the North of Africa. But wherever they came from nothing could be more likely than they must have been settled as a colony by the Pharaohs on the spot where Midian had been now found by Captain Burton. He had mentioned that at the head of the Gulf of Akabah there were some little islands, four of which he had specified, one bearing a name identical with that of one of the greatest of the Pharaohs, who might be called the mining Pharaoh—the Pharaoh who first, as far as they knew, wrought mines in the opposite peninsula of Sinai, precisely analagous to those which Captain Burton had now found in Midian.

Mr. J. H. Murchison said he had not the honour of Captain Burton's personal acquaintance, but he was well acquainted with his exploits, and the distinguished services he had rendered to this country. If there was one thing in the paper which struck him more than another, it was this—that while they had been obtaining their great mineral resources from countries which were known only by modern discoveries, Captain Burton had recalled their memories to countries which had been known, he might say, since the foundation of the world. They read in history that, centuries before the Christian era, the Egyptians enriched themselves by the copper mines of the Midianites; and at an equally early period the gold mines of that country were said to produce the fabulous sum of 70 millions sterling. Be that as it might, no one could deny that this country was one of the highest interest, and one which deserved their most serious consideration. Captain Burton had no doubt overcome difficulties which to many would have been insurmountable; and when they remembered that the colonies of England, which were the great supporters of her national industries, were her great sources for the supply of the precious metals, it was evident that, when this lecture was published, it would awake the world to the fact that there were other countries equally rich, which had been overlooked. As an old member, perhaps, the oldest present of the Society, he had much pleasure in proposing a cordial vote of thanks to Captain Burton for the able and interesting paper he had read, by far the most important he had ever listened to in that room.

Mr. Hawkins Johnson asked if Capt. Burton would give them an opportunity of inspecting the specimens he had brought home? Rocks and minerals were matters on the nature of which experts did not always agree, and he was sure there were many who would like to have an opportunity of judging of these things for themselves.

Mr. M. Dipnall asked if any specimens of ancient art had been found? They read in the book of Judges of the great spoil made under Gideon; and he should like to know if Captain Burton had found traces of anything like domestic industry or art, such as were sometimes found in other countries; and whether the gold mines, which had been worked in ancient times, now produced anything of which the Bedawin made any use in the way of art.

Mr. Lee Thomas asked if the quartz spoken of was in veins, which reached to any distance.

Captain Burton said they were large veins, chiefly in the grey granite, sometimes in the reddish granite; not completely syenite, with very little mica. Sometimes the veins were the breadth of a finger, at others 20 feet in breadth. In some parts of the country this formation formed a valley with a breadth of five or six miles; generally speaking, the hills rose in the form of truncated cones, to a maximum height of 600 feet.

Mr. J. Jones asked how Captain Burton knew that the old workings he visited were gold mines. By looking carefully amongst the *débris* of the old Welsh gold mines, you could find occasionally small pieces of gold which the miners had missed; and he should like to know if there were any similar indications in the mines of Midian.

Captain Burton said they had found visible gold in several different forms; one, which unfortunately was destroyed at Cairo, appeared to him to be volcanic and eruptive, the stone being honey-combed like lava. They found it in quartz, especially at its junction with the quartz and with the schist. It was also found in agate. The origin of his search was some gold-dust, brought to Cairo many years ago by a Turkish friend of his, who did not know he was a European. He had kept the

secret for 23 years, until a good opportunity occurred for utilising it, and on the strength of that he went to Midian.

The **Chairman** said that, after the lapse of many years, the whole character of a country became entirely changed, and what might have been upon the surface, and easily visible in the day of its prosperity, was so hidden and buried, that no one examining it for a few weeks only could tell much of the details. He could merely give, as Captain Burton had given, a brief and graphic outline of the country. They had heard a most interesting account of the country in which Joseph and his brethren sojurned, and this reminded him of Joseph's coat of many colours. He was not a Hebrew scholar, but he believed the word really described a garment made of a rich many-coloured material, like a Persian shawl, not a harlequin coat, such as many English people understood by the term. Many persons who had visited this country saw the mountains and torrid sandy district between them and the sea, and jumped hastily to the conclusion, that it was a waterless region, and consequently uninhabitable, but nothing could be more erroneous. Wherever there were mountains there must be water, simply because the mountains were condensers of rain; and the water trickled down in innumerable streams into the sandy plains. Very probably, when the land was occupied, this water was stored and used in irrigation, and it would certainly be exceedingly easy to collect any quantity of water of the purest quality from those mountain ranges. The sea coast had been described as being in some portions of a a bold character, and the water deep; and that was a necessary characteristic. If a traveller saw a bold cliffy coast, he might safely predict that there would be deep water alongside; for the contour of the land followed the same lines beneath water. Captain Burton had not treated them to any poetic descriptions of the country, but he might easily have done so. He (the Chairman) knew what these mountains looked like when the setting sun shone on then; he had seen them in Asia Minor, and they not only looked like glowing masses of fire, but like huge balloons lit up from the inside, sparkling out in the most marvellous manner. He had mentioned that gypsum was found very plentifully there, and also that the high region, the Nej, was the place where the most celebrated breed of Arab horses came from. Now, in some discussions they had had in that room with regard to water supply, it had been laid down that soft water was necessary, especially for horses, and more especially for race horses. They found what was stated in Layard's travels confirmed by Captain Burton, that this gypsum district produced the finest breed of horses in the world. Yet gypsum caused water to be hard, and it could not be softened by evaporation or boiling, because it was a sulphate of lime, which was not thrown down. He had also mentioned that the pilgrims who came from the shrine of Mohammed brought with them all sorts of zymotic diseases. This fact, he was sorry to say, was true of heathen pilgrimages in all parts of the world, for, as a member of the Army Sanitary Committee, he had had abundant evidence of the evils arising from the pilgrimages in India. Quarantine, no doubt, under certain conditions, might be necessary, but the idea of nations maintaining quarantines ought now to be exploded. The only method civilised man should adopt to deal with contagious diseases in the district he himself occupied, was by destroying the soil in which the seed could grow, and he might then cease to care about quarantine. During the Crimean War, quarantine throughout the East was abolished, and no evil effects resulted. All Easterns believed that the plague was contagious, and was especially likely to be conveyed by woollen garments; but during the time he was chairman of the Rivers Pollution Commission, he made special inquiries in Yorkshire with regard to shoddy, which was made from old woollen garments, brought from all parts of the world, including Egypt and all the plague infested regions. These old clothes were all picked over by hand before they were torn up for use again; but he could not find that any case of disease had ever been traced to them. Whether time had destroyed the disease by ferment he could not say, but such was the fact. Lastly, he would remark that, in opening up any such country as Midian, no use could be made of the minerals, unless there were roads, security for life, and safety for shipping. If there were a distance of from five to fifty miles to travel without roads, no minerals, unless they were diamonds, would pay for transit.

Captain Burton, in reply, said he was perfectly aware of the difficulty of finding pure lead, and that some of the best books asserted that it did not exist except under special circumstances. All he could say was that this lead was submitted to Colonel Rose, who made a trial of it, and told him that it was pure. It did not appear in veins, but was only found in small quartz, which had been scattered about the plain where there were certain signs of furnaces. He was told by the Arabs that it was to be found in the mountains, to the north-east; so that he could only answer for the little bits of quartz he found spalled, or broken designedly, probably in mining. He was very grateful to Mr. Haddan for the lift he had given him, and he hoped he would also give the mines of Midian a lift with his caravan railway. Mr. Cooper's remarks were admirable on the subject of Egyptology, which he had specially studied. The island at the north of the gulf of Akabah, called Pharaoh's Island, appeared to belong to every epoch; at the surface it was modern, and below you descended through the Roman and Greek to the Egyptian. It was not known to the Arabs as Pharaoh's Island, but there was a fortress upon it which was held by Christian crusaders. Another island in the great gulf was called Sinafr, which was by no means an Arab name, and, consequently, he thought it still maintained the tradition of Pharaoh Sinafru, who first began to mine for turquoises, and whose inscription still remained in Sinai. He was grateful to Mr. Murchison for his kind anticipation of the success of the mines, and he could assure him that nothing should be wanting on his part to make them successful. He did not think they would meet with any of the difficulties named by the Chairman, as there was no distance to travel. The richest mines were only four hours' walk from the coast, and the others not half-an-hour, and the people on the seaboard were perfectly friendly. The hostile tribe he had mentioned was far inland, and if he went again, he did not think he should have much difficulty even with them. The Bedawin made good workmen; and one tribe which had been there for many generations, showed remarkable mining instincts. When they were shown a particular stone, and told to bring others like it, they never made a mistake. In fact, for a fair day's wage, including food, he expected to get a fair day's work out of them. He had not brought any specimens with him, but he would take care that they were sent, either to that room, or to some place where they could be generally seen. With regard to art in Midian, the country had been very much destroyed; but they seemed to have been able to treat stone in a wonderful way, for he had specimens of granite hand-mills, probably used for grinding ores, most admirably made, and even showing the luxury of carving on them. He held in his hand a specimen, which showed that they had rather too much art, for it was an absolute proof that, before the days of Alexander, there were "smashers." It was an imitation of an Athenian tetradrachm, having a thin plate of silver outside, and a thick plate of copper inside. The Egyptians managed to "do" the Pharoahs by scooping out the interior of gold coins, and pouring in lead, and these people seemed to have been in no way inferior to them. The Chairman was quite right with regard to irrigation; in particular

places there were extensive channels, all revetted in stone, so as to keep the water from wandering, and one of the most peculiar features of the ruins was the completeness of the irrigational arrangements. The picturesque part of the narrative he had reserved for his forthcoming book. He also agreed with the Chairman about quarantine; but there was a difference between civilised people and the pilgrims from Mecca. Here you might shut off cases of disease, but there no one thought of anyone but himself; and the only safety was to keep him in quarantine until you knew he had no disease. It was certainly a barbarous measure, but neglect would be still worse.

The vote of thanks was then passed unanimously, and the meeting adjourned.

GENERAL NOTES.

The London Institute for the Advancement of Plain Needlework.—This institute was recently opened at 194, Westminster-bridge-road, by Miss Chessar, Mrs. Floyer, and other ladies. The names of Lady Sandford, Lady Alwyne Compton, Hon. A. T. E. Grosvenor, Mrs. Cromwell, and of several of H.M. Inspectors of Schools, are also associated with the institute. Its objects are:—1. To provide a central depot where all things connected with the systematic teaching of plain needlework may be examined. 2. To have a permanent exhibition, threefold in character, —*i.e.*, (1) Ancient plain needlework; (2) Model needlework; (3) Children's work, in grades or stages. 3. To exhibit samples of materials, fabrics, &c., best suited to exercise the children's powers in needlework. 4. To hold classes,—in the morning for persons not engaged in elementary teaching, and in the evening for persons above 21 years of age, employed as head or assistant teachers in public elementary schools. 5. To provide lectures on the systematic teaching of needlework, to be given from time to time. 6. To offer to persons desirous of qualifying themselves as "Specially Trained Teachers and Demonstrators in Plain Needlework" the opportunity of special teaching, similar to that given at Darmstadt and Reutlingen. 7. Examination pieces prepared, with all materials required, suitably graded for eaoh "stage" or "standard," for use at the Government inspeotor's visit, will be supplied, per hundred, at a moderate charge. The classes are conducted by Miss Bausch, from the Princess Alice-Verein, Darmstadt, and the work in London and at Watford is very flourishing, the classes having rapidly filled. The first course is on plain and advance darning—English, French, and German methods—patching, &c. It is proposed also to hold classes for teaching cutting out simultaneously, to be followed by classes in plain needlework, knitting, &c., on the German system.

Life of a Rail.—A correspondent sends the following results of experiments on the duration of steel and iron rails on the Cologne-Minden Railway:—

DESCRIPTION OF RAIL.	Laid in 1864.	Remaining in 1876.	Average wear of head.	Removals in twelve years.	
	No.	No.	millimetre.	No.	per ct.
Fine-grained Iron	150	29	...	121	80·66
Cast-hardened Iron	150	48	4·44	102	68·00
Puddle Steel	12	8	4·72	4	33·33
Puddle Steel	12	8		4	33·33
Bessemer Steel	149	142	5·22	7	4·70
Bessemer Steel	147	141	5·18	6	4·08
Bessemer Steel	150	148	4·18	2	1·33

The average wear of the experimental Bessemer rails is 4·86, which represents the effect produced by the passage of 6,500,000 axles of passenger and goods trains, or about 1,340,000 axles for each millimetre of wear.

NOTICES.

THE LIBRARY.

The following works have been presented to the Library:—

The Nautical Almanac for 1882. (London: John Murray, 1878.) Presented by the Lords Commissioners of the Admiralty.

Transactions of the Institution of Engineers and Shipbuilders in Scotland, Vol. 21. (Glasgow: Wm. Munro, 1878.) Presented by the Institution.

Minutes of the Proceedings of the Institution of Civil Engineers, Vol. 54, Session 1877-8.—Part 4. Edited by James Forrest. (London: Published by the Institution, 1878.) Presented by the Institution.

The following work has been purchased for the Library:—

Electric Lighting. A Practical Treatise by Hippolyte Fontaine, translated from the French by Paget Higgs, LL.D. (London: E. and F. N. Spon, 1878.)

THE JOURNAL.

Arrangements have been made for the transmission of the *Journal* in future entirely by post. All the copies of the *Journal* are now posted before the evening post of the Friday in each week, and members should receive them at least by the first morning post on Saturday. It is specially requested that any irregularity in the receipt of the *Journal* may be at once notified to the Secretary.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

The following arrangements for the Wednesday evenings before Christmas have been made:—

DECEMBER 4.—"Electric Lighting," by Mr. JAMES N. SHOOLBRED.

DECEMBER 11.—"Railways to Turkey and India." By Mr. HYDE CLARKE.

DECEMBER 18.—"Science Teaching in Elementary Schools." by Dr. J. H. GLADSTONE, F.R.S.

At the meetings after Christmas the following papers, amongst others, will be read:—

"The Distribution of Disease popularly considered." By Dr. ALFRED HAVILAND.

"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By Mr. JOSEPH J. POPE, M.R.C.S., L.S.A.

"The Best Methods for Improving the Condition of the Blind." By Dr. T. R. ARMITAGE.

"Indian Pottery at the Paris Exhibition." By Dr. G. BIRDWOOD, C.S.I.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock. First Course, on "Mathematical Instruments." Six Lectures, by Mr. W. MATTIEU WILLIAMS.

LECTURE II.—DECEMBER 2, 1878.

Standards of space-measurement, the yard, the metre, &c.—Standard of mass or gravitation, the pound, the

gramme, &c.—Thermometric and Calorimetric standards—Photometric standards—Electrical standards—Standards of value. *Instruments for the Direct Measurement of Lines, Surfaces, and Cubic Contents.*—Rules, scales, tapes, Gunter's chain, compasses, callipers, gauges, micrometers, pedometers, perambulators, opisometers, &c.—The planimeter—The device of Archimedes and its applications.

Lecture III.—December 9, 1878.

Instruments for Measuring Angles and Straight Lines by Triangulation. — Modes of expressing direction and angular measurement—Base lines—Necessity for horizontal or vertical datum—The plummet—The spirit-level. *The Theodolite taken as the typical and most complete Instrument for the Measurement of Angles by Direct Vision.*—Details of its construction—The patterns and castings—Hammering and trying, planing, filing up, smoothing and polishing of uprights, Y's semicircle, stage, &c.—The staff head—The parallel plates—The plate and limb—The horizontal and vertical axes, and precautions necessary for securing their truth—The divisions of the limb and semicircle—The verniers and magnifiers—The tangent and clamp screws—Grinding of the level tubes—The collimation of the telescope—The capture and manipulation of spiders—Wollaston's wire—The adjustment of the complete instrument—Various forms of theodolite.

Lecture IV.—December 16, 1878.

The altitude and azimuth instrument — The plane table—The prismatic compass and miner's dial—The surveying cross and optical square—The mural quadrant—Hadley's quadrant—The sextant—Troughton's reflecting circle—The artificial horizon—The goniometer—The transit telescope—The geometrical uses of the clock and chronometer — The equatorial telescope. *Instruments for Levelling, and the Direct Measurement of Altitudes.*—Simple levels without telescopes—The Y level—The dumpy level—Other forms of level—Levelling staves—The mountain barometer—The aneroid barometer. *Instruments for Measuring and Rectifying Curvature.* — The straight-edge and surface-plate — Sights—How to walk straight—The tripod micrometer and the measurement of curvature—The dip sector.

Lecture V.—January 20, 1879.

Instruments for Measuring Mass.—The scale beam—The steel yard — The spring balance — Laboratory balances—Cavendish's torsion balance for weighing the earth—Weighing the earth by plumb-line—Weighingthe earth by pendulum. *Instruments for Measuring Short Intervals of Time and Great Velocities.*—Wheatstone's and Foucault's mirrors—The chronograph—The spectroscope as applied to the measurement of velocities.

Lecture VI.—January 27, 1879.

Instruments for Recording or Representing Results of Mathematical Processes.—Plotting and Drawing Instruments.

These lectures will not be addressed to mathematicians, but the subject will be treated in simple and elementary forms; any technical term that must necessarily be used will be explained when introduced.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Household Sanitary Arrangements." It will consist of Six Lectures, to be given on the following dates:—

February 17, 24, March 3, 10, 17, 24.

The Third Course will be by Mr. W. H. Preece, on "Recent Advances in Telegraphy." It will consist of Five Lectures, to be given on the following dates:—

April 21, 28, May 5, 12, 19.

Juvenile Lectures.

The usual short course of lectures adapted for a juvenile audience will be given by Mr. W. R. S. Ralston, M.A., on "The Mythology of Fairy Tales." The dates for the lectures will be the 3rd and 10th January next. The lectures will commence at seven o'clock. Special tickets will be issued for these lectures.

MEETINGS FOR THE ENSUING WEEK.

Mon.... **SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Mattieu Williams, "Mathematical Instruments." (Lecture II.)

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Society of Engineers, 6, Westminster-chambers, 7½ p.m. Mr. James Atkinson, "Apparatus for Utilising the Waste Heat of Exhaust Steam."

British Architects, 9, Conduit-street, W., 8 p.m.

Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. Professor Noah Porter, "Science and Man."

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. T. H. Huxley, "The Elements of Psychology."

Tues.... Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. Wilson W. Phipson, "The Heating and Ventilating Apparatus of the Glasgow University."

Biblical Archæology, 33, Bloomsbury-street, W.C., 8½ p.m. 1. Professor Wm. Wright, LL.D., "Notes on a Bilingual Inscription in Latin and Aramic recently found at South Shields." 2. Mr. Theop. G. Pinches, "A New Fragment of the History of Nebuchadnezzar III." 3. Dr. Jules Oppert, "Babylonian Contracts."

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Prof. A. H. Garrod, "The Conformation of the Thoracic extremity of the Trachea in the class Aves. Part I. The *Gallinæ*." 2. Dr. A. Günther, "Reptiles from Midian, collected by Capt. Burton." 3. Mr. H. Seebohm, "A new *Sylvia* from Abyssinia."

Wed. ...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. J. N. Shoolbred, "Electric Lighting."

Geological, Burlington-house, W., 8. p.m. 1. Prof. T. G. Bonny and Mr. F. T. S. Haughton, "Some Mica-traps from the Kendal and Sedbergh Districts." 2. Mr. W. A. E. Ussher, "Pleistocene Notes on the Cornish Coast near Padstow." 3. Mr. W. A. E. Ussher, "The Pleistocene History of Cornwall." 4. Professor A. Leith Adams, "Remains of Mastodon and other Vertebrata of the Miocene Beds of the Maltese Islands."

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Rev. S. M. Mayhew, "Roman Remains recently Discovered at Lincoln." 2. Rev. Dr. Hooppell, "The Tenth Iter of Antoninus." 3. Mr. Romilly Allen, "Rock Markings at Ilkley."

Thurs...Linnean, Burlington-house, W., 8 p.m. 1. Mr. C. B. Clarke, "Note on *Gardenia turgida* (Roxb)." 2. Mr. D. F. Day, "Indian Fresh-water Fishes." 3. Dr. W. B. Kesteven, "Growth of *Melocactus communis*." 4. Mr. F. H. Waterhouse, "Some Coleoptera collected by Charles Darwin, of interest as regards Insular Fauna." 5. Mr. E. M. Holmes, "New British Moss." 6. Rev. R. Boog Watson, "Mollusca of *Challenger*." (II.)

Meteorological, 25, Great George-street, S.W., 7 p.m. Mr. Robert H. Scott, "The Nature, Methods, and General Objects of Meteorology."

Chemical, Burlington-house, W., 8 p.m. 1. Dr. Tidy, "The Processes and their Comparative Value for determining the quantity of Organic Matter in Potable Waters." Dr. Gladstone and Mr. Tribe, "Researches on the Action of the Copper-zinc Couple on Organic Compounds." 3. Dr. Dupré and Dr. Hake, "A New Gravimetric Method for the estimation of Minute Quantities of Carbon."

London Institution, Finsbury-circus, E.C., 7 p.m. Mr. J. Comyns Carr, "The Present Tendencies of English Art."

South London Photographic (at the House of the Society of Arts), 8 p.m. Popular Lantern Display.

Fri.......Philological, University College, W.C., 8 p.m.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,359. Vol. XXVII.

FRIDAY, DECEMBER 6, 1878.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

SCHOOL OF WOOD-CARVING.

With a view of encouraging the art of Wood-Carving in this country as a branch of the Fine Arts, the Council propose to apply to that object a grant placed at their disposal by the Drapers' Company, for promoting Technical Education, as they are at present in a position to secure the services of that eminent Florentine artist, Signor Bulletti, to take charge of the classes.

Messrs. Gillow and Co. have, with a view of aiding this national object, secured the use of a suitable house wherein to commence operations. They will also lend the necessary plant and models, and undertake to secure a sufficient amount of work for a year. On this basis it is hoped that a School of Art Wood-Carving may be established.

The Council will select and pay the fees for six months of four day students, who must undertake to attend during the whole of that time from 10 to 1, and 2 to 5, *at least*; and of four evening students, who must attend from 7 to 9, *at least*. Students must provide themselves with their own tools.

The Council reserve the right to cease paying the fees of any students whose instruction it appears useless to continue on account of their inattention or incapacity.

All Candidates for these Studentships must have passed the 2nd Grade Art Examination of the Science and Art Department in Freehand Drawing, at least. Those who have some knowledge of Wood-Carving, or have passed in the other subjects of the 2nd Grade Art Certificate, or in Drawing from the Antique and the Figure, Architectural Drawing or Designing, or in Modelling, will be preferred.

Candidates should send in their names at once, with particulars of their qualifications, such as the date and the place of examinations passed by them, to the Secretary of the Society of Arts.

JUVENILE LECTURES.

The usual short course of lectures adapted for a juvenile audience will be given by Mr. W. R. S. Ralston, M.A., on "The Mythology of Fairy Tales." The dates for the lectures will be the 3rd and 10th January next. The lectures will commence at seven o'clock. As the number of seats is limited, admission will be by ticket only, and when sufficient tickets have been issued to fill the Room, the issue will be discontinued. The tickets will be supplied strictly in the order in which the applications are received. Subject to these conditions, each member is entitled to a ticket admitting two children and one adult. Members requiring tickets are requested to make application to the Secretary.

THIRD ORDINARY MEETING.

Wednesday, December 4th, 1878; C. W. Siemens, D.C.L., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Burchell, William, 24, Red Lion-square, W.C., and 46, Gloucester-crescent, W.
Clemmence, John, jun., 9, Duke-street, Adelphi, W.C.
Dasent, Sir George Webbe, D.C.L., Belgrave-mansions, Grosvenor-gardens, S.W.
Harrison, Alfred, 3, Havelock-terrace, Sunderland.
Kilvington, William, Sunderland Engine Works, Sunderland.
Newton, John, Manor Works, Rotherhithe, S.E.
Pulvermacher, Isaac L., 194, Regent-street, W.
Turnbull, Alexander, 192, New City-road, Glasgow.
Whiting, Henry Gothwicke, 48, Colveston-crescent, West Hackney, E., and 46, Queen Victoria-street, E.C.

And as Honorary Corresponding Member:—

De Carranza, Commodore Don José, Royal Spanish Naval Commission, 57, Gracechurch-street, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Arbuthnot, Lieut.-Colonel George, R.A., M.P., F.R.G.S., 5, Upper Eccleston-street, S.W.
Bates, J. Walker, 5, Harrington-street, Liverpool.
Birch, Charles, 32, The Chase, Clapham-common, S.W.
Bird, Paul, 16, Hyde-park-place, W.
Bird, Samuel, 44, Belsize-park-gardens, N.W.
Birt, Alfred William, Dock-street, E.
Bodden, William, Oldham.
Busk, Charles Westly, 12, Vanbrugh-park, Blackheath, S.E.
Chadwick, William, Ponders-end, Middlesex.
Cook, John, Kingston-upon-Hull.
Cooper, Basil Henry, B.A., F.R.S.L., Fonthill-road, N.
Crowder, William, 2a, Evering-villas, Evering-road, Upper Clapton, E.
Datdah, Paul, Dinard, Ille et Vilaine, France.
Dean, Henry, 9, Milbrook-road, Brixton, S.W., and Deddington, Oxon.
De Rance, Charles E., F.G.S., 28, Jermyn-street, S.W., and Scientific Club, Savile-row, W.
Donaldson, John, Tower-house, Turnham-green.
Eastly, John, 86, Grange-road, S.E.
Edward, Charles, J.P., Park-lodge, Dundee.
Fearns, Francis Henry, Trafalgar Works, Old Kent-road, S.E., and Valentine-lodge, Peckham Rye, S.E.
FitzRoy, Major Cavendish C., 4, Cranley-place, Onslow-square, S.W.

Forsyth, William, Q.C., M.P., 61, Rutland-gate, S.W.
Froy, William Nathaniel, Brunswick Works, King-street, Hammersmith, W.
Furness, Edward, 74, Fleet-street, E.C.
Galsworthy, James, Grosvenor-road, Aldershot.
Godfrey, Albert Speed, Matson Red-house, Richmond, Surrey.
Gorzira, Cornelio, 30, Wellington-square, Oxford.
Graham, Alfred, 3rd Flat, 2 and 3, Tothill-street, Westminster, S.W.
Gray, John, Patent-office, Chancery-lane, W.C.
Gribble, William, 12, Abchurch-lane, E.C.
Hale, Charles, Lilian-villa, Barnes.
Halliday, Arthur, 92, High-street, Eton.
Hartley, General Marcellas, 19, Maiden-lane, New York.
Harvey, John James, 36, Stanhope-street, Euston-road, N.W.
Haughton, William, East India United Service Club, St. James's-square, S.W.
Hockey, Alfred Knibbs, Beccles, Suffolk.
Hughes, Ivor Edward, C.E., Milverton-lodge, Sydenham-hill-road, S.E.
Jackson, William, St. Neots, Huntingdonshire.
Joy, David, 11, Cavendish-park, Barrow-in-Furness.
Kinsman, Frederick, Indian Government Telegraph Department, Bombay.
Lloyd, Thomas, 4, Victoria-street, Westminster, S.W.
Lornie, John, F.S.S., Rosemount, Kirkcaldy, N.B.
Lucas, Arthur, 37, Duke-street, St. James's, S.W.
McAndrew, Major-General George, 34, Russell-road, Kensington, W.
McEvoy, Captain Charles Ambrose, 18, Adam-street, Adelphi, W.C.
McMurrough-Kavanagh, Frank, 9 and 10, Exchange-arcade, Manchester.
Marten, Henry John, C.E., 4, Storey's-gate, Westminster, S.W., and Parkfield-house, Wolverhampton.
Middleton, William John, 41, Belsize-avenue, South Hampstead, N.W.
Miller, Alexander, The Fishery, Chepstow.
Minami, Tamots, Imperial Japanese Consulate, 84, Bishopsgate-street, E.C.
Moses, Christopher, Worsley-house, North Ormesby, Middlesbrough.
Parker, William Colton, Whitehall Club, S.W.
Randall, W. F., 31, Stowe-road, Shepherd's Bush, W.
Richardson, Thomas Henry, Middlesbrough.
Ritchie, Frederick James, 25, Leith-street, Edinburgh.
Roberts, William Brittain, 4, St. Stephen's Church-villas, Shepherd's-bush, W.
Sedgwick, Alfred Owthwaite, North-end-house, Watford.
Seeley, Alfred, The Ferns, Onslow-road, Richmond-hill, Surrey.
Simms, James, Old Charlton, near Woolwich, S.E.
St. George, Percival Walter, City Surveyor's Office, Montreal, Canada.
Stower, Herbert S., 48, Lansdowne-road, W.
Sutton, Thomas Ashley, Irkdale Chemical Works, Smedley-road, Manchester.
Swanston, Geo. J., Board of Trade, Spring-gdns., S.W.
Turbervill, Malcolm W., 1, Everett-terrace, Walton-on-Naze, Essex.
Wardle, Thomas, 62, St. Edward-street, Leek.
Watts, Edwin Richard, 123, Camberwell-road, S.E.
Webster, Richard Everard, Q.C., 2, Pump-court, Temple, E.C.
Wesley-Church, John, H.M. Patent Office, Southampton-buildings, W.C.
Whalley, Cuthbert Wm., 14, Beaufort-sq., Chepstow.
Whateley, John, Lichfield.
Williams, George Joseph, 17, Cavendish-place, Cavendish-square, W.
Wood, Edward George, 74, Cheapside, E.C.

The paper read was—

ON THE PRACTICAL APPLICATION OF ELECTRICITY TO LIGHTING PURPOSES.

By James N. Shoolbred, B.A., Mem. Inst. C.E.

The object of the present communication is to present some of the results of a few of the actual applications of the electric light to illumination for industrial purposes, which have been in operation for a period of time and under such conditions as to cause each to have passed beyond the stage of a mere laboratory experiment. Any cases or processes which have not passed beyond this preliminary stage, or which have not yet received actual industrial application, have, as far as possible, been avoided.

The remarks which follow must be taken as the continuation of a communication "On the Present State of Electric Lighting," made last August to the British Association for the Advancement of Science, the purport of which was the description of some of the scientific tools, such as electric machines, lamps, carbons, &c., which are made use of in practical illumination by electricity; while the present communication will endeavour to give the commercial results of the working of those instruments.

A general knowledge of the principles and form of construction of the best known of these electrical machines and lamps will, therefore, be assumed, in order to avoid again travelling over the same ground.

Periods in Electric Illumination.

Electric lighting, it will be found, divides itself very readily into certain marked periods, each representing a clearly defined progress from that attained in the preceding one. It has been found convenient to divide them into three, which division will, in the following remarks, be still adhered to. These stages may be briefly described as—

1st. That of lighthouse illumination by the Holmes and by the Alliance magneto-electric machines, giving off currents alternating in direction, and producing a single very powerful light.

2nd. That of dynamo-electric machines producing a single light each, for industrial purposes generally, in addition to lighthouse illumination. The Siemens, and the earlier Gramme, are the best known in Europe of these machines; while the Wallace-Farmer and the Brush claim most attention in the United States.

3rd. That of machines both of magneto and of dynamo construction, and generally (though not necessarily) giving off alternate-direction currents; and which afford facilities, if provided with suitable lamps, for the production of a number of lights from each machine. Besides the already named Holmes and Alliance machines, and their recent and more compact successor, the De Meritens, all being of magneto construction, there are the Lontin (double) and the Gramme (double), which also effect this much desired object. In all these machines the current given off is alternating in direction. The two last-named machines, though dynamo in construction and in principle, are by some persons classed as magneto machines in their operation, inasmuch as the initial or generating machine of each maker acts like a permanent magnet to its second or

dividing machine, and affords to it a supply of electricity. Still, it may be replied, while the "generator" in each case most certainly acts on the dynamo principle, the "divider" does so also, as it greatly augments the electric current received from the former before it delivers it as its final output.

It may not be out of place here to mention, that the word "magneto" implies (to the author at least) a machine where permanent steel magnets are used to induce the electric current in an electro-magnet, *i.e.*, where a coil of copper wire is wound round a cast-iron core; while the term "dynamo" indicates that electro-magnets only have been used in the construction of both the inductor and the induction parts of the machine.

Practical Applications.

1st Stage.—*South Foreland and Souter Point Lighthouses.*—The Corporation of the Trinity-house first used the electric light at the South Foreland in March, 1859, then for several years at Dungeness, and they have made use regularly of the electric light as an illuminant, ever since 1871, in two of their lighthouses—at Souter Point, on the coast of Durham, and at the South Foreland, near to Dover. The apparatus employed in both cases is nearly the same. That at the last-named lighthouse formed part of the different electric apparatus made use of by Mr. James N. Douglass, the engineer to the Trinity Board, in his experiments at the South Foreland, to ascertain the relative merits of certain electric machines as available for lighthouse illumination, and it is described in his report upon those experiments.

It consists of two of Holmes' magneto-electric machines, used either singly or coupled up together, and driven by steam-engines of 10 h.p. nominal. The current given off in each case is alternating in direction, and serves to feed a Holmes lamp with square carbons, generally of $\frac{3}{8}$ inch a side, the rate of consumption of the carbons being about four inches per hour, the actual motor power per light ranging from 3 to 4 h.p. per hour, as indicated; while the intensity of the naked light produced has an hourly ordinary intensity (measured horizontally) of 1,523 standard sperm candles with a single machine, augmenting to a maximum of 3,046 candles when the two machines are coupled together. The annual cost of such lights, including engine power, carbons, wages of men, repairs, and interest at seven and a half per cent. on first cost, is about £539; this is for a total of 5,132 working hours during the year, and for a light of 1,523 candles.

Lighthouses at Cape La Heve, Havre, France.—An Alliance electric machine is provided for each of the two lighthouses. Each machine is composed of six discs, of 16 coils each, and affords a light of about 2,000 candles. The lighthouses were first lit up by electricity in 1863, and the illumination has continued regularly ever since. The following information as to expense has been kindly supplied by M. Allard, Inspecteur-Général des Phares, at Paris. The average annual cost, exclusive of interest, repairs, or depreciation, amounts to £660 for both lighthouses. If, for interest, depreciation, and repairs, £50 were added, this would stand at £710. The cost of maintaining a single light (in order to arrive at a precise parallel with the preceding case) is found to be about two-thirds of that where two lights are fed from a single source. This would, therefore, bring the annual expense at Havre down to about £474, for a light of about 2,000 candles intensity.

2nd Stage.—*Lizard Lighthouse.*—The Corporation of the Trinity-house, in consequence of the recommendation of Mr. Douglass, supported by Dr. Tyndall, the result of the experiments at the South Foreland just referred to, have established, now nearly twelve months ago, at this their latest application of the electric light, a series of six Siemens dynamo-electric machines, each of the type known as "4,000 candles;" and these are driven by three caloric engines. Of the three electric engines thus formed, a single one may be driven, under ordinary circumstances, to produce one light of an hourly intensity of 4,100 standard candles; or else the two may be coupled together, as in the case in thick weather, and an intensity of 8,500 candles afforded to the light; the average amount of motor power per hour for a single machine being about three horses. The annual working expenses, under similar conditions to the preceding case, came to about £500 for a light of 4,100 candles. The results at the Lizard Point, therefore, to a more abundant light produced at a cheaper rate absolutely than with the older machines at Souter Point and at the South Foreland.

While considering these applications of the electric light to lighthouse illumination, it is but right to remark that they take place under circumstances and conditions special to themselves, and which do not exist in the case of industrial or other works. These arise in part from the paramount necessity of providing in the lighthouse an illumination of the most perfect character, and abundant in intensity; as well as of providing an amount of extra plant to guard against any cessation in the illumination. The generally isolated situation of the lighthouse also adds to the cost of the materials employed, and causes the personal staff employed to be of a more skilled class, than where assistance in the matter of repairs is readily available. Any comparison, on purely economical grounds, between the electric illumination in lighthouses and in industrial works, must necessarily be unfavourable to the former.

Northern of France Railway Goods Station at La Chapelle, Paris.—This company, finding that the night work done in the goods sheds and in the yard outside was very inferior in amount to that done during the day (about 37 per cent. per head), and that, moreover, a considerable number of small articles were mislaid and lost during the night-work, determined to try the electric light to improve matters.

A series of 6 single-light "Gramme" machines were provided, each of the size termed "A" (6,000 candles), and a portable engine of 15 h.-p. nominal. A special shed was erected to contain the electric machines and the engine. Several forms of lamp were tried, but that made by Serrin was ultimately preferred; latterly, however, a modification of that lamp by Suisse has been used with great advantage, as it allows of 12 hours' consecutive burning, in place of only $3\frac{1}{2}$ with the original Serrin. The average length of the night-work was found to be 10 hours, with a

maximum of 15 hours. The first outlay (intended for five-light centres) consisted of six machines, six lamps, portable engine, shed, conducting cables, &c.; this, fixed complete, amounted to £1,640. The electric lights were placed, one in a goods shed, the remainder in the open yard, so as to light up a row of turn tables, where most of the night-work took place. The shed is 230 feet long, and 75 feet wide, with an open roof 33 feet high at the ridge, and 16 feet at the eaves, and having a central skylight along each side for most of its length; the upper portion of the walls and the underside of the roof were whitened to aid in reflection. The electric light is hung near to the centre, in a simple lantern of ground glass, and at an elevation of 15 feet from the ground. The result of this illumination was to increase the efficiency of the night-work by 30 per cent. The original imperfect gas illumination had been carried on by means of 21 jets, burning 4¼ cubic feet each. The new illumination was as effective as if these had been augmented to from 50 to 55, causing a hourly consumption of 220 cubic feet of gas. The light in the shed was found to give a good working light for a distance from it of over 100 feet, while those outside were satisfactory within a radius of 200 feet. The electric illumination commenced on January 15th, 1877, and has continued regularly ever since.

During this period a series of careful experiments were carried out by the officers of the company. The results showed that on an average 2½ actual h.p. was required per light per hour, sometimes a little more, sometimes rather less; and that the square carbons, of ⅜ inch a side, were consumed at the rate of 4 inches per hour, or at a cost of 1½d., waste included.

The nightly working expenses, with an average of four lights, and during ten hours, were found to be—

	s.	d.
Motor power—2·5 h.p. × 7·8 lbs. coal × 10 hours × 4 lamps	7	0
Carbons—4 lamps × 10 hours × 1½d. (nearly)	4	10
Oil 8d., wood 1½d., lighting engine shed 2½d....	1	0
Engineman's wages	4	0
	16	10

This gives a price per light per hour of 5d., add to this 10 per cent. on first outlay of £1,640, for interest and depreciation, 2¾d.; total cost per light per hour 7¾d. (say 8d.). This, to the railway company, would represent the cost of 22 gas jets, while the electric light, in the shed, was considered to have satisfactorily replaced 52 jets, thus leaving an economy of 30 jets, or about 60 per cent. in favour of the electric light.

Iron Works of Messrs. T. and T. Powell, Rouen.—In the autumn of 1876, Messrs. Powell determined to illuminate a newly-made erecting shop with electric light. It is a building 125 ft. long by 45 ft. broad, with an open roof 26 ft. high at the eaves, and 40 ft. at the ridge.

Two single-light Gramme machines, of the small or "M" size, with two Serrin lamps, conducting cables, &c., were provided, and fixed complete for £196. The lamps were suspended under the centre of the shed, 60 ft. apart from each other, and at a height of 30 ft. from the ground. No special motor was provided, the requisite power being taken from the engine which served to give motion to the tools, &c. A series of carefully taken indicator diagrams showed that, on an average, 2½ indicated h.-p. was absorbed by each light, which was found to contain an intensity of 1,900 candles (measured horizontally). This illumination (costing actually 4d. per hour per light) would come out, if with an allowance for a special engine, and 12 per cent. for interest and depreciation, at a total expense of 2s. 10d. per hour; as against 7s. 7d. for an equally effective illumination with gas, at 7s. 8d. per thousand cubic feet, the price in Rouen.

Messrs. Powell, after two years' experience of the working of the electric illumination, and finding it so much cheaper, more effective, and safer than gas would be in their erecting shed, have decided to extend it without delay to the rest of their works.

A very considerable number of applications of this class of single-light electric machines, both of the Siemens and of the Gramme construction, exist in France and in this country, and serve for the illumination of industrial works differing very widely in character. The data, however, given in the above examples afford some test as to the capabilities and as to the working expenses of this class of machines.

3RD STAGE.—*Paris, Lyons, and Mediterranean Railway Company.—Paris Terminus.*—This company having decided to try the effect of the Lontin electric light, gave permission to the patentees of that system to enter upon a period of preliminary trial at their passenger station, to enable the company to judge of the efficiency and economy of the illumination before finally adopting it. Twenty-eight electric lights distributed about the station, and replacing 172 gas jets, were supplied with electricity by a combination of one generating and two dividing machines all upon the Lontin system. The lamps used were the modification of the Serrin, introduced by M. Lontin, whereby a number can be employed upon one circuit (where only one of the original Serrin can be used). The power of each of these dividing machines was that known as of "18,000 candles." The motor power for this temporary arrangement was a Brotherhood 3-cylinder engine, supplied by steam from an old locomotive (lent by the railway company). This arrangement proved, however, to be wasteful in steam. The effective illuminating power of each electric lamp was considered to be equal to that of 80 gas jets. The average cost of the 28 electric lamps during these preliminary trials would appear to have been about 8s. 2d. (10·25 francs) per hour. This preliminary experience lasted from September 7th to October 28th, 1877. The result was, however, sufficient to satisfy the railway company as to the effectiveness of electric illumination, and as to the possibility of its being carried on without interruption, and it induced them to enter into a contract with the patentees of the Lontin system to light up, for a period of twelve months, a large receiving-shed in their goods station of the same terminus. Twelve lights were to be provided, all emanating from one dividing machine. The total cost per hour was 5s. (6 francs), or 5d. (0·50 franc) per light; the contractors finding everything requisite, except water, and bearing all working expenses.

Western of France Railway,—Paris Terminus St.

Lazare.—This railway decided, in the early part of 1878, to try the Lontin system of electric lighting at this station.

Goods Yard.—The patentees of this system commenced, in May last, to light up the goods yard, on the arrival side. For this purpose, six electric lights are placed against the columns which carry the roof, at a height of about 12 ft. from the ground. They are provided with electricity from a Lontin (double) machine, of the type known as of "12,000 candles."

The motor power is afforded by an agricultural engine of 9 h.p. nominal, the piston being $9\frac{1}{2}$ in. in diameter and $13\frac{1}{8}$ in. stroke, the average pressure in the boiler being 83 lbs. per square inch, and 110 the average number of revolutions per minute of the fly wheel, the total hourly consumption of coal per hour being about 80 lbs. The lights were found, by a series of careful experiments, to be of a mean luminous intensity of 480 candles each. They are generally left naked, without any shade, without any ill effect being produced upon the persons below.

The lamps used are the Serrin, modified by Lontin, so as to admit of several being placed upon one circuit; in this instance they are placed in pairs, six lamps upon three circuits. The consumption of the $\frac{3}{8}$ in. round carbons was found to be at the rate of $1\frac{1}{2}$d. per light per hour.

The average working expenses of these six lights are, per hour—

Coal, &c., for engine, at 32s. per ton	1s.	2d.
Carbons for six lamps		8d.
Engineman and stoker		10d.
Total hourly cost for six lamps..	2s.	8d.
Or per light per hour	$5\frac{1}{2}$d.	
Add for interest on outlay for depreciation and repairs	$2\frac{1}{2}$d.	
Total hourly expense of each light	8d.	

Passenger Station (*Departure side*), "*Salle des Pas Perdus.*"—In the month of June, the directors of the railway company determined to extend the electric illumination to this portion of the station. Accordingly, the patentees of the Lontin light fixed for this purpose twelve lights, supplied from an "18,000 candles" Lontin machine, which was placed, together with an agricultural engine of 12 h.-p. nominal, at first in the cellars of the station, near to the Rue St. Lazare. It was afterwards removed up on to the station itself, in a shed constructed for the purpose. This removal necessitated some interruptions in the regular lighting. The engine is of the following dimensions:—Diameter of piston, $11\frac{7}{8}$ inches; length of stroke, 13 inches; revolution of fly-wheel per minute, 110; average boiler pressure 93 lbs. per square inch.

Each electric lamp is enclosed in a ground glass circular lantern, in form of an inverted truncated cone, with a metal top to it, while the body of the lamp protruding below the lantern is placed in an ornamental bronze case, the entire having an appearance of an elegant moderator lamp.

The difference in the illumination between this side of the station and the goods yard side, where the lights are naked, is very marked; and leaves an impression very much in favour of the enclosed lights, which diffuse the illumination and render it more uniform. The effect in the large hall called the "Salle des Pas Perdus," which is 445 feet long, 66 feet wide, and 20 feet high at eaves, and nearly 40 feet at ridge, is very good. Five lamps from the centre, suspended at an elevation of about 18 feet from the ground, light up this fine hall.

The twelve electric lights in this part of the station are placed upon three circuits; four lamps upon each.

Street Lighting in Paris. — The Jablochkoff "Candle."—Of the various streets and other places lit up by this system, the Avenue de l'Opera is the one which, from its central position, has attracted most attention, and, therefore, will be taken here as a type example.

The Avenue de l'Opera, including the Place de l'Opera at one end, and the Place du Theatre Français, are lit up by 62 lights; 46 single-candle and eight double-candle (on the Place de l'Opera). Originally, only about 40 were provided, but the illumination being insufficient the number was augmented (at the contractor's expense) to the amount just stated.

These are divided into four groups; one on the Place de l'Opera, two in the Avenue de l'Opera, and one on the Place du Theatre Français. Each group of lights is supplied with electricity from a (double) Gramme "16 light" machine, driven by an engine of 20 nominal h.p.

A very considerable amount of mystery has been kept up by the patentees of this system as to the cost of it. The expense they state it to be is (1·06 francs) 11d., nearly, per light per hour, which they hope, so it is said, shortly to reduce by one half. However, the payment to the patentees by the City of Paris is at a rate of 1·25 francs per hour on each of the original lights stipulated in the contract, the augmentation to 62 being entirely gratuitous by the contractor, and in order to keep up an effective illumination. The total remuneration is 37·2 francs (29s. 9d.) per hour. The original gas illumination consisted of 344 jets, and costs 7·224 francs (6s.) per hour. The electric illumination is considered, however, as equal to 682 gas jets, say, to double the original illumination; that is, to a cost of 14·45 francs per hour, as against 37·2 francs for the electric one. The latter, therefore, cost 2·6 times that of the gas of equal illuminating intensity.

Need it be added that the City of Paris have terminated the contract with the last day of November.

The contractors have, however, offered to continue the contract at the reduced rate of 0·60 franc (6d.) per light per hour. The Municipal Council of Paris have declined to continue any contract, except provisionally, up to January 15th, 1879, and that only at the rate of the original cost of the gas, viz., at a total expense of 7·224 francs (6s. nearly) per hour. By information lately received from Mons. Allard, the chief engineer of the lighting department of the City of Paris (under the engineer-in-chief, Mons. Alphand), and by whom the above details have been kindly communicated, the contractors for the lighting, the Societé Générale d'Electricité, have consented to undertake the lighting at the above reduced rate. The price paid to them, therefore, will be, up to

January 15th next, at the highly remunerative rate of about 1⅛d. per light per hour.

A series of very careful photometric measurements, carried out by the Municipal authorities in the Avenue de l'Opera itself with the existing illumination, showed each light to possess a maximum of 300 candles of intensity with the naked light; while, by the interposition of the opaque globe, the maximum was reduced to 180 candles (a loss of 40 per cent.), and this again to a minimum of 90 candles during the darker periods through which this light passed.

Many other applications of the Jablochkoff candles with the Gramme machine occur in Paris, such as at the Magazins and the Hotel du Louvre, at the Theatre du Chatelet, at the Hippodrome, at the Hotel Continental, &c. Still, as in none of these cases have the financial results been ascertained on such good authority as in the case of the Avenue de l'Opera, it has been thought advisable to pass them over. The main object, held constantly in view in the present communication, has been to ascertain the carefully prepared financial results of a few applications, which have been supplied on unimpeachable authority, rather than to attempt to present those of a larger number, in some of which the results might have been open to doubt.

Rapieff Light at the "Times" Office, London.—So much attention has, in this country at least, been drawn to this, one of the latest novelties in the application of the electric light, an interest due mainly to the peculiar form of lamp used in conjunction with the Gramme machine, that one can hardly conclude this brief notice of electric light applications without saying a short word about it. A Gramme (double) "16-light" machine has been provided at the *Times* office by the proprietors, together with an engine suitable even for future emergencies, and a portion of the lights, six in number, in the machine room, all in one circuit, have been set in place. A much larger addition to the number, in other parts of the building, is shortly contemplated.

Owing to the fact that only a portion of the intended application has so far been got to work, and that only recently (since October 12th last), it is not possible, nor hardly fair, yet to judge of the actual results. Still the system works fairly, and it may therefore be entitled to take rank as an established application of electric illumination.

In the preceding remarks on the various applications of electric lighting to illuminating purposes many, very many, of a highly interesting character have been omitted. Amongst these might be named those for military and naval purposes, for the construction of large works out of doors, such as docks, bridges, &c., for weaving and spinning operations (where the purity of the electric light is of peculiar advantage), for agricultural, and for other classes of night-work, too numerous even to name. This omission has been necessitated partly from want of time, partly from want of those very careful and even scientifically-prepared results which were desired. It is hoped, however, that the few and carefully selected examples presented will afford some slight guide as to the results, financial and otherwise, which effective electrical illumination may be expected to afford.

LUMINOUS INTENSITY.

Continuous { Lemmonier—Gramme. / Douglass—Siemens.

Alternating { Allard—Alliance. / Lafaurie—Lontin. / Allard—Jablochkoff.

Irregularities—Lafaurie { Yellow from Electricity. / Red ,, Lamp. / Green ,, Neutral.

MOTIVE POWER.

Mechanical Questions.

Divers Motors { Steam. / Gas. / Water. / Hydro-carbon.

DISCUSSION.

The Chairman said the electric light was not a thing of yesterday. The first proposal to produce light by electricity dated back to Sir Humphrey Davy and the beginning of this century. Sir Humphrey Davy produced a very brilliant arc with 3,000 Wollaston cells; and shortly afterwards a still larger arc was produced with 600 Bunsen cells. They were now approaching the end of the century, and were still wondering whether the electric light would be a success. The difficulty which immediately presented itself was its great cost; for to maintain 600 Bunsen cells for a single light meant an expenditure which put the light altogether out of the question for commercial purposes. It was not until 1831 that a new ray of light was thrown upon this question, through the brilliant discovery of Prof. Faraday. In that year he elicited an electric spark from a steel magnet; and, small as it appeared, it was the origin of a great revolution in the applied arts. The effects obtained by the experiment were very small, and it was not until Pixii, in 1833, constructed an electro-magnetic machine, which was soon after improved upon by Clarke, that a continuous succession of electric sparks or currents was obtained by means of a permanent magnet. This was taken advantage of by Prof. Holmes, in 1856, when he constructed his celebrated magneto-electric machine, which was still used for illuminating many light-houses in France and elsewhere. The next important step was the invention or discovery of magneto-electric currents, which was claimed by several men of science. Prof. Wheatstone and himself had brought papers before the Royal Society at the same time, and his brother had brought one before the Berlin Society somewhat earlier. No doubt, as often happened, the same idea occurred to them all. Mr. Varley, although he did not publish what he had done until lately, had also worked in the same direction. With the dynamo-electric machine they had the power of magnetism developing a current, turning mechanical energy into electrical energy, without much loss, for the loss for converting energy into current was not more than 30 per cent.; this was less than the result obtained in any other mechanical conversion. With this power, therefore, they had an engine which converted mechanical force into electrical force, and that electrical force into light, by a process which was now perfectly well understood. There remained, however the further question to be solved:—Given the power of the light, how could it be put in such form as to be suitable for the purposes of mankind? The room was at present lighted by one of his own electric lamps, worked by his machine. He was sorry to say that it had not always been steady; but this want of steadiness was not the fault of the lamp. If the motive force had been uniform, the light would have been uniform; and he had just been informed that at the time when a considerable alteration

took place, the steam in the little engine used to drive the machine had fallen from 70 lbs. pressure to 55 lbs., and the dynamo-machine was brought almost to a standstill. It was always a difficulty, in temporary arrangements, to maintain steam at anything like a steady pressure, and hitches always occurred in getting up hurried experiments. There was, however, a more serious difficulty in the electric lamps of the present day, namely, the carbon consumed; for its re-adjustment required mechanism which was not yet absolutely perfect, nor was the carbon absolutely perfect. Great improvement had been made in the carbon rods, and he had worked an electric lamp which for hours remained almost absolutely steady; but when the power varied, the imperfections of the carbon also showed themselves in an increased degree. Mr. Shoolbred had alluded to a great many proposals for overcoming the practical difficulties which now stood in the way of making the electric light successful. There were two different systems; the one with fixed carbons along with alternate currents, of which the Jablochkoff was a type, and the other with a continuous current. The reversed current had many advantages for distributing and subdividing the light, whereas the fixed had the advantage of being more economical. He considered that, in resorting to reversed currents, and bringing the light down to the position which gas lamps generally occupied, 60 to 70 per cent. of the maximum effect was sacrificed, and the result was that the electric light was expensive; whereas if concentrated, and distributed over a large area, it could be got cheaply. It was only for the engineer who had the arrangement of it to make it face in such a way as not to be inconvenient. He had heard a great deal about inventions for subdividing the electric light indefinitely, but he did not attach so great an importance to that, as the electric light would not take the place of gas for our streets or in our houses, though it would come in largely for lighting halls and large public places of every description; but even if they could subdivide the light to any extent, it would be found that such sub-division would reduce the economy. As far as his experience went, it was rather a question of concentrating than subdividing.

Mr. Hale thought the reader of the paper ought to have stated whether he thought the electric light would be suitable for domestic use in the future.

Mr. James N. Douglass said he had been connected with the electric illumination of lighthouses for many years, and he remembered how, at one time, Faraday was highly pleased with the light, and thought it was a pity it was so expensive. At the present time, thanks to Messrs. Siemens, the light was produced at about one-fourth of the cost at which it stood 14 or 15 years ago. With regard to steadiness, at the Souter Point Lighthouse, the electric light had been shown continuously for eight years, with only two stoppages, on one occasion when the light-keeper went to sleep, and on the other, owing to a bad carbon; a piece of the carbon fell and broke the contact, and there was a temporary suspension. An oil lamp was always provided, in case of accident, and it was burned one hour a week in order to be sure it was in readiness, but they never had occasion to use it. On the question of cost, of course, a lighthouse was no criterion; but at the present time, putting aside the cost of plant and attendance, they could, with 1 lb. of coal, produce nearly twenty times the amount of light which coal would yield if distilled into gas. That being the case, he thought the question might be safely left to the mechanic. Allowing for the cost of carbons, they got about ten times the amount of light to that produced by coal distillation. With regard to subdivision he should be inclined to agree with the Chairman. They had heard nothing lately from Mr. Edison, and he thought there was still hope for gas shareholders in domestic illumination, though for large places there was no doubt a cheaper and more efficient illuminant in electricity.

Mr. F. W. Hartley asked whether the estimates of illuminating power had been taken at the maximum, minimum, or mean? As an old photometrist, also, he should like to know what system of photometry was employed, and he was rather inclined to doubt whether any system would enable an accurate comparison to be made with the electric light. The eye was always very liable to be deceived by intensity.

Sir Charles Bright said that great improvements had been made during the last few years in the machines for generating the current. He thought the great point for inventors to turn their attention to now was the lamp itself, which was as yet far from perfect. Several were before them in the room, and there were about 30 patents still unspecified, but he was not at all sure that the right thing was yet obtained.

Mr. Spencer thought the great question at the present time was whether the electric light could be distributed without loss. There was a diagram showing how the current from one machine could be divided into 12. What he should like to know was, whether each separate current was equal to $\frac{1}{12}$ of the whole?

Mr. Applegarth, in the absence of Mr. Rapieff, explained the construction and action of his lamp. The main object was to secure that if an accidental interruption of the current, or an extinction of the voltaic arc took place, the extinction should be as of short duration as possible. There was a small magnet at the bottom of the lamp, and if an extinction took place, this magnet came into operation, and brought the carbons together almost simultaneously. The Rapieff light was now in use at the *Times* office, where it could be seen on application on any Tuesday or Friday evening; and it would have been shown that evening, but there was not sufficient time to prepare for it, and he preferred not lighting it at all to running the risk of failure. Mr. Shoolbred said it was necessary for the Rapieff light to stand upright, but that was not so. In the particular form exhibited it was; but, as the carbon was actuated by gravity, it was perfectly easy to make them approach horizontally as well as perpendicularly. He showed a new lamp with vertical carbons set side by side, and separated by a narrow air space, like the Jablochkoff candle with its separating layer of kaolin. The difference between Rapieff's *bougie electrique* and the Jablochkoff candle was this—that Rapieff took the carbons as they came from the factory, put them into his candlestick, and burned them; whereas Jablochkoff had to put the carbon into a factory, to be made into a candle, with the insulating substance between. Now, all insulating substances, when cold, were non-conductors, but when hot they became conductors, and consequently as soon as the insulating substance became hot, part of the electricity was conducted down to the earth, and was lost for the purpose of illumination. There were now six lights in the machine-room of the *Times*, and they were going to put up six others in the composing room When that was done he was sure it would be successful; and they would have killed two birds with one stone, viz., shown the suitability of the light for the most delicate purposes, and get rid of that extreme heat which was killing many good men who had to work all night by gas-light. He did not believe that electricity would take the place of gas for domestic purposes, at any rate in this century, but it was very suitable for large public buildings and manufactories, and it was useless for gas companies to shut their eyes to this fact.

Mr. W. H. Preece said some ingenious statisticians had endeavoured to show that famines, potato disease, and other things of that kind, had regular periodical recurrences, and amongst these periodical strange sensations must be now included the electric light, for it had more or less repeated itself regularly at periods of

ten years. In 1847, the National Gallery, the Duke of York's Column, Trafalgar-square, and the Polytechnic were illuminated by the electric light, and Dr. Baehhoffner used to attract audiences like the present to see it; but after a fitful existence it disappeared. It came to light again in 1857, when some one in Belgium, whose name he forgot, succeeded in subdividing the light, and, as he thought, producing a light ten times as cheap as gas; but he failed. The attention of Faraday was directed to the matter, and, with the aid of Professor Holmes, the electric light was made a practical thing for the time being. The Trinity-house took it up; it was tried at the South Foreland, and was practically applied to the Dungeness light-house in 1862, but from that time to this they had really advanced very little. This would be seen by referring to Professor Fleeming Jenkin's report in that year, wherein would be found almost everything which had lately re-appeared on the subject. When the Prince of Wales was married, in 1863, Professor Pepper tried to light up the dome of St. Paul's, and a little flicker was seen, but nothing more; Mr. Ladd succeeded better in throwing a light on the Monument, and one or two other public buildings in London were lit by the new light. In 1867, at the commencement of the next decennial period, several electric lamps were shown in the Paris Exhibition by Leroux and others, but it again died out, until quite lately. He did not pretend to run down the electric light, or to crack up gas, for, in his opinion, each had its own sphere. He belonged to a large establishment where a great many hands were employed, and their gas bill came to thousands of pounds a year, so that it was a matter of extreme urgency to find a light which would be superior, not on the score of economy, but to do away with the vitiation of the air, which was so unhealthy. He went to Paris, and everywhere where the electric light could be seen, but he had laid down three desiderata, which he had not yet found accomplished. The first was that the light must be absolutely steady; secondly, it must be brilliant, giving a light of 1,000 candles, or more; thirdly, it must be durable. Of all the lights, the only one he had seen which came up to his standard of brilliancy was the Serrin, of which the one they had seen that night was a modification; the only one which came up to his criterion of steadiness was the Werdermann; and the only one sufficiently durable was the Wallace, by which he meant one which would last all night, and nights in England sometimes lasted 18 hours. But there were several which came pretty near these criteria. The Rapieff seemed very efficient, but it was not quite good enough, and, therefore, they had not yet introduced the light into the Post-office. His attention had been much directed to the subdivision, but it seemed to him a kind of *ignis fatuus*, or philosopher's stone, for this simple reason, that the experiments he had examined showed that when you divided the light, the intensity diminished as the square. Now, if you had an increase in your family, and at the same time your income diminished by the square of the mouths you had to feed, the result would very soon be the workhouse. He looked upon the subdivision of the light as a practical impossibility. At the same time, he had not made these experiments himself, but they were to be found in the last chapter of Fontaine's work on the electric light. Other experiments had been made with incandescent light, of which so much fuss had been made in America. He did not know much about this Edison light, but he knew Mr. Edison. He visited him in America some two years ago, and spent two very pleasant days in Mr. Edison's laboratory. He was an extremely ingenious man, but his ingenuity often carried him to extremes. He was an American of the Americans. It was said of an American infant that he would improve his cradle, get out and patent it, and get back again. Mr. Edison had taken out 269 patents, but he only knew of three that were at work. Not having seen Mr. Edison's light, he could not say very much about it, but he feared he had tumbled into a tremendous mare's nest, and that with two 80 h.p. engines, and a lot of money, he was going to flounder out of it. He thought that it was not in the shape of subdivision, but of condensation, that the light would be improved and made fit for use; and, for the purpose of illuminating large rooms, workshops, railway stations, squares, and things of that kind, the electric light would come out of its present difficulties, and be, in fact, the light of the future.

Mr. W. H. Bennett asked what practical means had been adopted for determining the illuminating power of the electric light; because it was manifest that the ordinary photometer was not adapted for the purpose?

Mr. Ladd said he had been working at this subject for a good many years, and he might therefore say a few words. He did not wish to alarm gas shareholders, for if he had any gas shares he would keep them, but he simply wished to call attention to the Wallace lamp, specimens of which were on the table. He was quite certain that of all the lamps he had seen, there was none to equal this for durability or steadiness. One of them would burn for 100 hours. It was used for days and nights in a factory, and for many hours burnt continuously. There was no clock-work in them; but simply an electro-magnet, which worked so instantaneously that you could scarcely see a flicker. Moreover, they were so constant that, with a Wallace lamp, you could get six or eight lamps burning in a circuit. Something had been said by Mr. Shoolbred about the Lontin machine giving six or seven lamps in circuit, but this was not so, as anyone could see by going to the Gaiety and examining the lamps for themselves. There were six or eight lights burning, but there were as many services leading to them, which meant a very different thing from one circuit. There was a wire for each lamp, and one return wire for the whole. In the Wallace machines and lamps they led two wires from the machine, and connected each lamp to them, for as many as were required. They reckoned one horse-power for each light, and one for the wire. If they wanted additional light, all that was required was to put on a little more steam and speed, and you could get three, four, or more lights, accordingly. They had been invited to show the light, but there was not sufficient time to fit it up properly. There was no difficulty in getting rod carbons, such as were used in most lamps, but the plate carbons used in the Wallace lamp had to be made specially. One lot had been made, but being dried too rapidly, split in pieces, and another lot was now being made. The advantage of this was that there was a large body of carbon sufficient to convey the whole of the current, whilst the small ones in the Jablochkoff current necessarily lost a good deal. The plates were also much cheaper, taking into account the time for which they burned.

Mr. Shoolbred, in reply to Mr. Hartley, said he had shown in two of the diagrams both the maximum and minimum light, and it was evident that this had been taken into consideration in making the comparison. With regard to the difficulty of making a comparison of light, he was informed that the gentleman who took the observations of the Lontin light did his utmost to obtain a fair comparison; he tried different coloured glasses, and found that some favoured one light, and some the other, and the one which most assimilated them was green, and he accordingly carried out his operations by the aid of green glass. With regard to the duration, he understood that the Suisse lamp had been in use for 12 or 14 hours consecutively. In conclusion, he must thank all those gentlemen, and they were numerous, who had aided him in divers ways in the preparation of the communication which he had made to the meeting; and most especially to Messrs. Siemens for the trouble and expense they had

most kindly put themselves to in providing a practical exhibition of electric illumination throughout the entire evening, and by which the room had been lit up. Such a test was of a very severe character, as the slightest flicker, or irregularity, or noise, must be more noticeable in the quiet necessary during a scientific meeting, than would be the case under ordinary circumstances. He, himself, throughout the entire time he had been occupied in reading, had been pleasantly struck by the absence of flickering and noise, which were much less than he had experienced during so long a period with any electric light on any previous occasion. The irregularities which had occurred in the light during the latter part of the evening, were quite accounted for by the sudden variations in the boiler pressure. It was not fair, therefore, to lay the blame of those irregularities upon the light.

The Chairman, in proposing a vote of thanks to Mr. Shoolbred, said he could not agree with Sir Charles Bright, that it was the lamp which was principally at fault; on the present occasion the fault was with the engine. He did not wonder that the proprietors of other lamps had declined to risk a failure, by exhibiting their apparatus without sufficient time to ensure success; but people who came to the Society did not come for scenic effects, but to study a question. The lamp had not been touched all the evening, so that the occasional unsteadiness was evidently due to the defective working of the engine. Mr. Shoolbred had gone to a great deal of trouble in preparing the diagrams and collecting information, and he had much pleasure in proposing a cordial vote of thanks to him.

Lord Alfred Churchill proposed a similar compliment to the chairman and the gentlemen who had sent the apparatus. In doing so he remarked that, as one of the most convenient sources of power for producing the electric current was certainly a gas engine, such as they had seen at work in the room below, gas shareholders might take comfort to themselves.

The resolution was carried, and the meeting adjourned.

During the whole of the evening the great room was lighted by a Siemens' lamp hung from the centre of the ceiling, and worked by a Siemens' machine placed in the yard at the back of the premises. The machine was one of those mounted on the same base as a small three-cylinder Brotherhood engine, by which it is driven. To supply steam, a boiler was lent by Messrs. Appleby Bros. Below the great room, in the library, was placed an eight horse-power gas engine, lent by Messrs. Crossley Bros., of Manchester; this drove three Gramme machines, one large size, known as the "A" Gramme, and two of the "M" size, the smallest size made. The two small Grammes were lent by M. Rapieff; the large Gramme machine was lent by the India-rubber, Gutta-percha, and Telegraph Works Company, of Silvertown, and was nearly the first, if not actually the first, made in this country; it was employed to work a Suisse lamp in the ante-room, and a Hallé lamp in the entrance hall, lent by the same company. Besides these, the following lamps were exhibited but not lighted:—

By Mr. J. Douglass, of the Trinity-house—Two Holmes lamps, one of which was used experimentally, in 1859, at the South Foreland Lighthouse, and the other an improved form, used since 1871 at the Soutar Point and South Foreland Lighthouses.

By Messrs. Paterson—Three varieties of the Serrin lamp and a Gaiffe lamp.

By M. Suisse—Two Suisse lamps.

By the Société Générale d'Electricité—Specimens of Jablochkoff candle.

By Mr. Ladd—Two Wallace-Farmer lamps, one for factory use, to show a naked light, and one for use in a lantern.

By Mr. Rapieff—A number of his lamps, showing the different arrangements employed in them.

The Council wish to express their sense of the obligation which the Society is under to the above firms and individual gentlemen, for the liberality with which they placed so much valuable apparatus at the disposal of the Society.

MISCELLANEOUS.

COUNTY ASSOCIATIONS FOR THE CULTIVATION OF MUSIC.—MANCHESTER BRANCH.

On the 26th November, 1878, a meeting was held at Owens College, in the History Lecture Theatre, for establishing a Manchester branch of the Lancashire Association for the Cultivation of Music among all, the **Dean of Manchester** presiding, in the absence of the Bishop, who is president of the association, and who was ill. There were present the Earl of Wilton, the Bishop of Salford, Sir Henry Cole, K.C.B., Mr Oliver Heywood, Dr. Greenwood, the Rev. Dr. Burton, and many others interested in Musical Education.

The Chairman said that the Bishop was extremely sorry that he could not be present, but he was confined to his house, as he had been for some days, and had lost his voice through cold. That meeting had been called by the Lancashire Association for the Cultivation of Music among all, to establish a Music School in Manchester, respecting which Sir Henry Cole would no doubt give some information. The testimony of Mr. Hullah, her Majesty's Inspector in Music, was that the children in the national schools generally learnt by ear what little singing they acquired, and that, as a rule, they had no scientific knowledge of music whatever. This was a state of affairs for which the association wished to substitute the teaching of music on scientific principles. If the Government granted nearly £100,000 a year for instructing children in music, and he understood that this was the case, properly qualified teachers of music must be wanted, for those who were best able to speak on this subject considered that the present practice in elementary schools, of teaching singing by ear, was not worth paying for. It would be one of the first objects of this association to provide such teachers.

Sir Henry Cole, hon. secretary of the association, moved:—"That this meeting approves the preliminary steps which have been taken to establish a Lancashire Association for Promoting Music as an Art, especially useful to the general culture and recreation of all classes, and resolves that those who have already joined the association, do form its committee, with power to add to their number, and appoint an executive committee to frame rules and do what is necessary." Having explained that the association had not originated with Owens College, he said that, unlike the National Training School of Music, London, the object of which was to assist genius, that association desired to give a sense of music to everybody. The influence of the association had been already felt. More than 100 clergymen of the Church of England had memorialised the Government to improve the teaching of music in elementary schools, and the School Board of Manchester had sent rather a strong petition containing the same request. The Bishop of Salford had held a conference with his clergy, to see what he could do in this direction, and though he (Sir Henry Cole) had not heard of any general movement among Nonconformist ministers, he had received from some of them, including the Rev. W. Gaskell, expressions of their desire to aid the movement. What the association proposed to do at first, was of a modest character, and he thought that it would be quite within their present means. They were prepared at once

to establish at Owens College Classes ten free musical scholarships, which would be offered to elementary school teachers, and others who might be willing and able to become special instructors in music to elementary schools. Candidates would be admitted to the scholarships after an examination, which would be conducted by Mr. Hecht, the Owens College lecturer on harmony and musical composition. The scholars would be required to join the harmony and composition classes at the college, and if they could read music at sight they would be enabled to join the choral class. The subjects for the examination to which he had alluded, would be notes, keys, and time; and preference would of course be given to the candidates with good voices and correct ears. At the end of their term of instruction, the scholars would be again examined, and certificates and prizes awarded to those who were worthy of them. A resolution was also to be proposed on a subject which he approached with some little hesitation —viz., that of assistance from the Corporation of Manchester. The Corporation very properly aided music already. It had spent the ratepayers' money on a fine organ, and it was going to obtain a peal of bells to play various tunes. Why, then, should not the Corporation assist this movement for improving the musical education of the people generally? Ireland had power by Act of Parliament to enable Corporations to help music. Cork had already done so, and Manchester ought not to appear less enlightened; as the love of music was one of the most potent forces which could be brought to bear against evil habits.

The **Earl of Wilton** seconded the motion, and advocated the encouragement of music among the people, especially in Lancashire, where music was so loved. He had done all he could in his own neighbourhood, and found that nothing had such a powerful influence in drawing working men from the public houses as the introduction of music into their homes. The motion was carried unanimously.

The **Rev. Dr. Burton** moved :—"That as soon as practicable, and when the time is favourable, a school of music be established in Manchester, where teachers for giving instruction in public elementary schools may be trained, and that in the meantime 10 free scholarships shall be awarded by public competition, to be held at a musical class already existing in the city."

Mr. W. H. J. Traice, secretary of the Lancashire and Cheshire Union of Institutes, seconded the resolution, which was unanimously adopted.

Sir Henry Cole, who had now taken the chair, in consequence of the Dean having being unable to remain till the close of the proceedings, said that Dr. Greenwood, in his private capacity, would bring forward a resolution.

Dr. Greenwood proposed:—"That a deputation wait upon the Corporation, to request that, like free libraries, public parks, and museums, music may be promoted by the Corporation, as most desirable for the general culture and recreation of the people of the city of Manchester and its suburbs." He said that, in proportion as music was cultivated among the labouring classes they were more easily weaned from drunkenness and other vices, and therefore the Corporation would be aiding the most worthy and important of all causes if they acceded to the request mentioned in the resolution.

The Rev. E. P. Anderson seconded the motion, which was agreed to.

Votes of thanks to the Dean and Sir Henry Cole brought the meeting to a close.

This is the first county association for promoting generally the cultivation of music which has been formed, and means will be taken to interest the Members of the Society to cause others to be formed in other counties. Some movement has been made already in Devonshire, and in Yorkshire.

CORRESPONDENCE.

PURIFICATION OF DIRTY FILTERS.

The following may be useful to those who are using ordinary domestic filters:—

I have had in use for some time a filter, which, like many others, has a chamber in which the filtering material is concealed and cemented up in a very unsatisfactory manner, rendering a ready view of its condition impossible, and its cleansing a difficulty. I was about to smash the partition, use the vessel as a flower-pot, and buy or make a filter wherein the filtering material is easily moveable, and may be readily and cheaply cleansed or renewed. Before doing this, I tried the following experiment:—I took out the old, dirty sponge, replaced it by a new one, made a solution of permanganate of potass, and passed that through and through the filter. The result has been so satisfactory, that the old filter has not become a flower-pot, but remains still in use.

To repeat this, dissolve a few crystals (two or three grains to a gallon are quite sufficient) of permanganate of potass in as much water as will fully charge the filter. The solution should be strong enough to have a deep rose-pink colour. Run this through. If all the colour comes out, repeat the operation with fresh solution until the pink colour, somewhat paled, remains in the filtered liquid. Then pass through two or three full charges of ordinary water, and the filter is ready for use again.

The permanganate acts by oxidising any organic matter retained in the filtering strata. It carbonises such matter pretty nearly in the same way as though it were burned, leaving behind the carbon thus produced as an addition to the filtering material, and, besides this, a similarly small contribution of oxide of manganese, which is also a good filtering medium. The discolouration of the permanganate solution proves that work is done in the oxidation of dangerous organic accumulation, and the amount of this work is indicated by the number of charges passed through and drawn out colourless.

I have little doubt that a solution of the so-called "chloride of lime" would answer the purpose if passed through in like manner, and followed by the further passing through of ordinary water to remove the traces of flavour of the hypochlorous acid that it would leave behind, but I have only tried the permanganate solution.

W. Mattieu Williams.

THE PREVENTION OF COLLIERY EXPLOSIONS.

The recent catastrophe at Abercarne has again called public attention to the subject of colliery explosions. It may interest your readers to know that these calamities are not inevitable. Sixty-two years ago the Society of Arts made the extraordinary award of a hundred guineas and the large gold medal to James Ryan, the most scientific of mining engineers, who introduced a system of ventilation by the employment of which safety lamps were dispensed with and colliery explosions altogether avoided. As you are aware, the present system of ventilation is conducted by means of a furnace at the bottom of the up-cast shaft, or a rotatory fan at the top, or by means of a steam jet alone or in combination with the furnace below; the object of which is, by suction or pressure, to produce a current of atmospheric air throughout the mine. It is deemed that a rapid current of air dilutes and drives away the gas evolved from the coal. But when we know that a change in the weather will cause a large evolution of gas, when we

know that upwards of thirty millions cubic feet of gas have been evolved from a pit during the course of three or four days (*vide* James Mather's evidence before the Parliamentary Committee of 1852), we need not be surprised that explosions occur, notwithstanding the breezy nature of the air below, for in that case, a good supply of oxygen is all that is necessary to form a highly explosive mixture, which, coming in contact with a naked light, or the so-called safety lamp, immediately explodes the mine. Now, James Ryan was the first mining engineer who approached the evil at the fountain-head. He constructed a gas drift, and thus diverted the course of, and drained away, the explosive gas. His plans are very fully described and illustrated in the "Transactions" of the Society of Arts for the year 1816. After describing all the technical details of his system, Ryan says:—"In order to elucidate the matter still further, I will give the following analogy;—If a large thin book be placed in a slanting position on a bed of clay or stone, and covered with another bed or stratum, equally impervious to gas, it may represent a seam of coal, which is separated into laminæ correspondent to the leaves of paper. This is precisely the case in those mines where the seam of coal runs out to the surface uninterrupted by 'faults' (or dykes); in such mines explosions are never known. But when the seam is separated by a 'fault,' which, to pursue our illustration, may be imitated by cutting the book in two, with its supporting and superincumbent strata of clay, raising or depressing one portion until the leaves of the book, no longer touching each other, rest against the clay, and *vice versâ*—such a 'fault,' it is evident, will no longer permit the free transmission of the noxious gas into the atmosphere from the portion of leaves situate below the 'fault,' whilst that part which still presents its higher edge to the surface continues as safe as before. In this case, I bore a sufficient quantity of holes from the seam below the 'fault' (or down-cast) to the seam above it (or up-cast), in order to let the gas pursue its course." So much for the theory; now for the practical work. Ryan's system of ventilation was in use in the Dudley district from 1808 to 1844—a test of thirty-six years. During that period no explosion took place, although, before the adoption of his plans, explosions there were both frequent and fatal. The "Transactions" contain certificates from the owners and managers of the Buffery and Netherton mines, in Staffordshire, respecting the efficacy of Ryan's system, which had then been in use eight years. Once convinced of the utility of this means of preventing colliery explosions, the question arises, why has it not been generally adopted long ago? That is a question I should like colliery viewers and Government inspectors to answer. John Martin, the historical painter, who took an interest in these matters, and whose brother introduced the first real safety lamp, stated many years ago that the owners of collieries allow their managers a premium for working dangerous or very fiery mines. Whether this accounts for their apathy I cannot say. But it is singular they should have neglected the best means of preventing colliery explosions.

T. S. Horn.

Addiscombe.

GENERAL NOTES.

Electric Lamps.—In the *Journal* of the 22nd November an account was given of the principal regulators employed in the production of the electric light. The description of the Wallace-Farmer lamp requires to be amended in one important particular. The lamp does not need any hand adjustment, as would appear from the statement made. As soon as the space between the carbons is such as to offer sufficient resistance, the armature is released by the magnet, and the upper carbon falls till it is in contact with the lower one, and the circuit is again complete. The upper carbon holder is not fixed to the armature, but slides in its attachment, and is gripped by a catch actuated by the magnet. The effect of this arrangement is that whenever the magnet grows weak the carbon drops, not only the distance allowed by the play of the armature, but as much further as is required to bring it down to the lower carbon. The magnet then causes the clip to grasp the holder, and raises it a certain definite distance, such as is found to be the best for the formation of the arc. This distance is adjustable by hand, and depends on the amount of play allowed to the armature. The lamps are stated to burn for a hundred hours without attention.

Institution of Mechanical Engineers.—It is announced that this institution is prepared to devote a part of its funds to the purpose of research on unsettled mechanical questions, both in collecting and collating such information as already exists, and in completing it, where required, by new experiments. The matter has not yet taken a fixed shape, but in the meantime the secretary has been instructed to get together what information he can on the three following specimen subjects:—(1.) The causes and conditions of the hardening and tempering of steel. (2.) The relative effects of various corrosive agents on typical specimens of iron and steel. (3.) The best design of riveted joints, both in iron and steel. As information on such subjects is widely scattered and difficult to trace, the secretary asks for references to any sources of such information known to exist, and would be glad to have indicated the means of procuring copies of any of the publications which may be difficult of access. Further information of any kind would also be welcomed, and suitably acknowledged by the Council.

NOTICES.

THE JOURNAL.

The *Journal* is now posted before the evening post of the Friday in each week, and members should receive it at least by the first morning post on Saturday. It is specially requested that any irregularity in the receipt of the *Journal* may be at once notified to the Secretary.

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

The following arrangements for the Wednesday evenings before Christmas have been made:—

December 11.—"Railways to Turkey and India." By Mr. Hyde Clarke. Sir Henry Tyler will preside.

December 18.—"Science Teaching in Elementary Schools," by Dr. J. H. Gladstone, F.R.S.

At the meetings after Christmas the following papers, amongst others, will be read:—

"The Distribution of Disease popularly considered.' By Dr. Alfred Haviland.

"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By Mr. Joseph J. Pope, M.R.C.S., L.S.A.

"The Best Methods for Improving the Condition of the Blind." By Dr. T. R. Armitage.

"Indian Pottery at the Paris Exhibition." By Dr. G. Birdwood, C.S.I.

Indian Section.

The meetings of this Section will take place

on the following Friday Evenings, at Eight o'clock:—

January 31, February 21, March 7, April 4, May 2 and 23

African Section.

The meetings of this Section will take place on the following Tuesday Evenings, at Eight o'clock:—

January 21, February 4, March 18, April 1 and 29, May 27.

Chemical Section.

The meetings of this Section will take place on the following Thursday Evenings at Eight o'clock:—

January 23, February 13, March 13 and 27, April 24, May 22.

Cantor Lectures.

Monday Evenings, at Eight o'clock. First Course, on "Mathematical Instruments." Six Lectures, by Mr. W. Mattieu Williams.

Lecture III.—December 9, 1878.

Instruments for Measuring Angles and Straight Lines by Triangulation. — Modes of expressing direction and angular measurement—Base lines—Necessity for horizontal or vertical datum—The plummet—The spirit-level. *The Theodolite taken as the typical and most complete Instrument for the Measurement of Angles by Direct Vision.*—Details of its construction—The patterns and castings—Hammering and trying, planing, filing up, smoothing and polishing of uprights, Y's semicircle, stage, &c.—The staff head—The parallel plates—The plate and limb—The horizontal and vertical axes, and precautions necessary for securing their truth—The divisions of the limb and semicircle—The verniers and magnifiers—The tangent and clamp screws—Grinding of the level tubes—The collimation of the telescope—The capture and manipulation of spiders—Wollaston's wire—The adjustment of the complete instrument—Various forms of theodolite.

Lecture IV.—December 16, 1878.

The altitude and azimuth instrument — The plane table—The prismatic compass and miner's dial—The surveying cross and optical square—The mural quadrant—Hadley's quadrant—The sextant—Troughton's reflecting circle—The artificial horizon—The goniometer—The transit telescope—The geometrical uses of the clock and chronometer — The equatorial telescope. *Instruments for Levelling, and the Direct Measurement of Altitudes.*—Simple levels without telescopes—The Y level—The dumpy level—Other forms of level—Levelling staves—The mountain barometer—The aneroid barometer. *Instruments for Measuring and Rectifying Curvature.* — The straight-edge and surface-plate — Sights—How to walk straight—The tripod micrometer and the measurement of curvature—The dip sector.

Lecture V.—January 20, 1879.

Instruments for Measuring Mass.—The scale beam—The steel yard — The spring balance — Laboratory balances—Cavendish's torsion balance for weighing the earth—Weighing the earth by plumb-line—Weighing the earth by pendulum. *Instruments for Measuring Short Intervals of Time and Great Velocities.*—Wheatstone's and Foucault's mirrors—The chronograph—The spectroscope as applied to the measurement of velocities.

Lecture VI.—January 27, 1879.

Instruments for Recording or Representing Results of Mathematical Processes.—Plotting and Drawing Instruments.

These lectures will not be addressed to mathematicians, but the subject will be treated in simple and elementary forms; any technical term that must necessarily be used will be explained when introduced.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Household Sanitary Arrangements." It will consist of Six Lectures, to be given on the following dates:—

February 17, 24, March 3, 10, 17, 24.

The Third Course will be by Mr. W. H. Preece, on "Recent Advances in Telegraphy." It will consist of Five Lectures, to be given on the following dates:—

April 21, 28, May 5, 12, 19.

MEETINGS FOR THE ENSUING WEEK.

Mon.... **SOCIETY OF ARTS,** John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Mattieu Williams, "Mathematical Instruments." (Lecture III.)
Charity Organisation Society (at the House of the Society of Arts), 4 p.m. Paper on "The Organisation of Unremunerative Industry."
Farmers' Club, Caledonian Hotel, Adelphi, W.C., 5½ p.m. Mr. J. K. Fowler, "The Paris Exhibition: its Agricultural Teachings."
Institute of Surveyors, 12, Great George-street, S.W. 8 p.m. Mr. T. F. Hedley, "The Rating of Railways, with Suggestions for the Amendment of the Law."
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. C. R. Markham, 1. "The Swedish Arctic Expedition;" 2. "The Dutch Arctic Expedition;" 3. "The Route for future Polar Discovery."
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Francis Darwin, "Self Defence among Plants."

Tues.... Central Chamber of Agriculture (at the House of the Society of Arts), 11 a.m.
Frœbel Society (at the House of the Society of Arts), 7½ p.m. Fraulein Heerwart, "The Transition Class; or, What we expect of Children on Leaving the Kindergarten."
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Discussion on "Heating and Ventilating Buildings;" and, time permitting, Mr. W. Furniss Potter, "Railway Work in Japan."
Farmers' Club, Caledonian Hotel, Adelphi, W.C., 4 p.m. Annual Meeting.
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Captain Richard F. Burton, "Finds in Midian;" 2. Prof. R. Owen and Mr. C. Carter Blake, "Notes on Skulls from Midian;" 3. Dr. Henry Muirhead, "Left-Handedness."

Wed. ...**SOCIETY OF ARTS,** John-street, Adelphi, W.C., 8 p.m. Mr. Hyde Clarke, "Railways to Turkey and India."
Microscopical, King's College, W.C., 8 p.m. 1. Dr. Hudson, "*Oecistes ophagni* (a new species) and other Rotifers." 2. Mr. F. H. Ward, "A New Microspectroscope without a Slit." 3. Mr. F. Crisp, "Hoffman's New Form of Camera Lucida."

Thur....Sanitary Institute (at the House of the Society of Arts), 4 p.m. Special General Meeting.
London Institution, Finsbury-circus, E.C., 7 p.m. Prof. W. H. Flowers, "Wingless Birds, Fossil and Living."
Royal Historical, 11, Chandos-street, W., 8 p.m. 1. Dr. George Harris, "Domestic Every-day Life, Manners, and Customs in this Country. Part IV.—From the End of the Thirteenth to the End of the Sixteenth Century." 2. Rev. A. H. Wratislaw, "Life and Literary Remains of Vladimer Monomachus, Grand Prince of Kyjev; obit. A.D. 1125."
Mathematical, 22, Albemarle-street, W., 8 p.m. 1. Mr. H. Perigal, "Motion." 2. Mr. S. Roberts, "Forms of Numbers Determined by Continued Fractions." 3. Prince Camille de Polignac, "A Graphic Construction of the Powers of a Linear Substitution."

Fri.......Quekett Microscopical Club, University College, W.C., 8 p.m.

Sat......Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Mr. C. Boys, "A Condenser of Variable Capacity." 2. Dr. O. J. Lodge, "A Differential Air Thermometer."

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No. 1,360. Vol. XXVII.

FRIDAY, DECEMBER 13, 1878.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

INSTITUTIONS.

The following Institution has been received into Union since the last announcement:—

Agricultural, Industrial, and Commercial School, Aspatria, near Carlisle.

JUVENILE LECTURES.

The usual short course of lectures adapted for a juvenile audience will be given by Mr. W. R. S. Ralston, M.A., on "The Mythology of Fairy Tales." The dates for the lectures will be the 3rd and 10th January next. The lectures will commence at seven o'clock. As the number of seats is limited, admission will be by ticket only, and when sufficient tickets have been issued to fill the Room, the issue will be discontinued. The tickets will be supplied strictly in the order in which the applications are received. Subject to these conditions, each member is entitled to a ticket admitting two children and one adult. The tickets will be issued in the course of a few days, and members requiring them are requested to make application to the Secretary.

Members who have already applied are informed that their applications have been noted, and that they will receive their tickets shortly.

FOURTH ORDINARY MEETING.

Wednesday, December 11th, 1878; Sir Henry W. Tyler, R.E., in the chair.

The following candidates were proposed for election as members of the Society:—

Atkin, Frederick, Mortomley, near Sheffield.
Flower, Frank, 3, Piccadilly, W.
Meyer, M. R., 16, Mark-lane, E.C.
Miller, David, Beachley, near Chepstow.
Orange, William, M.D., Broadmoor, Wokingham, Berkshire.
Reid, James, Hyde-park Locomotive Works, Glasgow.
Vernon, Thomas, C.E., Tonedale-villa, Cheltenham.
Webber, William Downes, J. P. Mitchelstown Castle, Co. Cork.

The following candidates were balloted for and duly elected members of the Society:—

Allsup, William James, F.R.A.S., 5, Eastcombe-villas, Blackheath, S.E.
Haddan, John Lawton, 25, Great George-street, S.W.
Humm, Moses, 707, Commercial-road, E., and Chester-lodge, Loughton, Essex.
Marsland, Robert, 21, Grosvenor-street, Camberwell-road, S.E.
Mercer, Francis Montier, 59, Bishopsgate-street Within, E.C.
Preece, W. H., Telegraph Department, General Post-office, E.C., and Gothic-lodge, Wimbledon.
Preston, Richard, Tottington, near Bury, Lancashire.
Soames, J. K., Thames Soap Works, Greenwich, S.E., and 21, Vanbrugh-park, Blackheath, S.E.
Walker, Walter Frederick, 3, Moore-park-villas, Walham-green, S.W.

The paper read was—

ON RAILWAYS TO INDIA AND TURKEY.

By Hyde Clarke.

From the moment that England had become possessed of an empire in India, the question of overland or direct communication acquired importance and attracted interest. This is very well illustrated, so far as the close of the last century and beginning of this are concerned, in the memoirs of Mr. Barker, formerly consul at Aleppo. The progress of the matter has, however, been very slow. The occupation of Egypt by the English three-quarters of a century ago, though it proved the practicability of such communication, did little to advance it. It was by two great projects of our time that progress was made; one was that of Lieutenant Waghorn, who succeeded in establishing overland transit through Egypt; the other—not yet accomplished—the expedition of General Chesney, for communication between the Mediterranean and the Persian Gulf. The Egyptian route is too familiar to take up our time, particularly since the development of the Suez Canal by M. Lesseps. The other, as it is yet to be put in operation, the rather demands our attention.

The plan of the navigation of the Tigris, in consequence of the importance acquired by the railway systems in Europe, soon became subordinate to the plan devised—also by General Chesney—for a Euphrates railway. To the promotion of this Mr. W. P. Andrew has devoted himself for a quarter of a century. Through his persistent advocacy, the Euphrates plan has become popularly known, and has attracted popular attention beyond even the main subject of through communication from England to India.

It is interesting, and at the same time painful, to see how many dead and living had long applied themselves to the advancement of such an undertaking. The progress of railways through France, Germany, and Austria, as naturally drew attention to the through route, as the establishment of steam navigation in the Mediterranean did to the Egyptian and Euphrates routes.

General Chesney, whose labours can never be overrated, was among the first to project a through route. In 1842, Mr. William Pare, then well known in the railway world, published a plan for a Calais, Constantinople, and Calcutta railway, and be it borne in mind that Mr. Pare was a

railway traffic computer. Mr. Alexander F. Campbell, formerly of the Royal Engineers, proposed to the old East India Company a system of railways on the wide gauge to India, under dates 6th September, 1843, 25th March, 1845, and 28th April, 1845. His map was published by Mr. Wyld, in 1851. Mr. John Wright, in 1849, took up the same subject, and wrote upon it, under the title "Christianity and Commerce, the Natural Results of the Progression of Railways." Dr. James Bowen Thompson, a zealous promoter of the Euphrates route, and who died at Constantinople while engaged in its advocacy, displayed in the Great Exhibition of 1851 a plan for a railway from London to Calcutta.

About the time Mr. W. P. Andrew took up the Euphrates route, Sir R. M. Stephenson did the same in 1850 and 1851, but he adopted the alternative project of a Persian route. In 1859, on the ground of ill-health, he gave up the agitation, having, however, done much by his writings and personal exertions to advance the cause of the through railway. To this he devoted himself, seeing clearly that when the European system reached Constantinople, it must cross the Bosphorus.

While apathy has affected English and Indian officials, the cause in which they had engaged was never abandoned by the distinguished staff of the Tigris and Euphrates Expedition, and those allied with them. Following their leader, General Chesney, great service was rendered by Captain H. B. Lynch, R.N., and his brothers, Mr. W. F. Ainsworth, General Estcourt, Lieutenant Murphy, Captain Campbell, I.M., and Captain Felix Jones, whose great loss has been so lately lamented. The contributions of Mrs. Chesney towards the mission of her late husband must not be forgotten.

Continual and weighty efforts have been made to impress the home and Indian Governments. In 1857, Mr. W. P. Andrew led to Lord Palmerston a powerful deputation, and was its organ. Indeed, it may be said that from that time scarcely a year has passed without something from his pen on that subject.

My attention was early directed to this subject, and, being in Turkey, I had the opportunity of pressing it on the Ottoman Government, and seconding the efforts of its supporters. My consultations with the Grand Vizier, Fuad Pasha, induced him, in 1863, to give me the mission of negotiating for placing the whole railway, from the Danube to Bagdad. A change in the money market, and an indisposition on his part to make a further small concession in interest, caused this attempt to fail.

This was, however, only one of the series of efforts of the Ottoman Government to carry out what they justly looked upon as one chief measure for the regeneration and reinvigoration of the empire in Europe and in Asia. In attempting this, under great difficulties, the indifference of their friends, and the open and covert intrigues of their enemies, although they have achieved a large measure of success, they have not proved strong enough, and have had to subject the country to heavy sacrifices.

In 1867, they had divided their portion of the through railway into sections; one in Europe, known as the Rumelian, and the other in Asia. The former concession was placed ultimately in the hands of Baron Hirsch, and, although most of the lines have been made, except the break at Belgrade, the financial operations have been of the disastrous character which attended all weak foreign Governments that, at that epoch, fell into the hands of financiers.

The other, the Asia Minor section, was conceded to the Hon. Captain Randolph Stewart, and, on his invitation, I co-operated with him. On this occasion I laid before this Society a paper,* on the 26th Feb., 1868, on "A Daily Mail Route to India," and a paper before the Royal United Service Institution, in the same year, on the "Military and Political Advantages of a Through Railway to India." After great efforts, Captain Stewart was unsuccessful in carrying his concession into effect.

The opening of the Suez Canal, under French political auspices, created great attention, and renewed efforts were made to awaken the Government to the necessity of assisting the through line. On the motion of Sir George Jenkinson, seconded by Sir George Balfour, two staunch friends of the cause, a Committee of the House of Commons was granted. Before this committee valuable evidence was given by Sir H. Rawlinson, Mr. Ainsworth, Mr. Telford Macneill, Mr. Palgrave, Mr. Maxwell, and others, but no practical result was obtained. In that year, on the 22nd November, through the Society of Arts, I endeavoured to draw the notice of the public to the necessity of taking measures, by reading here a paper "On the Progress of the Through Railway Route to India."† It may be permitted me to remark on this paper, that its title well represents the state of the case; it indicated the progress of the through route, and notwithstanding obstacles and difficulties, the condition has been one of progress from year to year and from time to time, and this is the ground for hope and persistence at this very period of great difficulty and discouragement, when the Stafford-house Committee are hesitating and halting. It is because the plan of a through railway to India is of a practical character, and meets actual wants, that it makes progress, and must be accomplished. It makes, however, all the difference to those of us who are now alive in England, in India, and in Australia, whether this work shall be proceeded with in earnest, or still longer be left to the chapter of accidents.

Not only has the undertaking made progress beyond the prophecies of those who defended it, but there have been such resources applied as, under due arrangement, should, by this time, have opened the whole line to Bagdad. The sacrifice of capital on the Rumelian lines, the Varna, the Kustenji, and others, has been of a serious nature, while the credit of Turkey has been allowed, by corrupt intrigues and political treachery, to be utterly wrecked. Thus the resources which would have been available now for carrying out what is wanted no longer exist, and new means must be provided. It is impossible, after careful and candid consideration, to avoid the conviction that very different results might have been obtained, had there been a really sincere and intelligent administration by our Government of its relations with Turkey. We have stood by with indifference to see money dissipated by jobbers, which in reality could have

* *Journal of the Society of Arts*, Feb. 28, 1868, vol. xvi., p. 276.
† *Journal of the Society of Arts*, Nov. 26th, 1871, Vol. xx., p. 992.

been applied to our own national advantage, while in the end thousands of families in this country have been involved in the wanton ruin of Turkey.

It is to be hoped that the time has come for another course of action, and that a more enlightened policy will prevail, and permit us to retrieve the losses of the past, and to achieve better results in the future. It is indeed evident that the fortunes of many now suffering in England are dependent on the restoration, by means of these railways, of Asia Minor.

Having paused to consider what might have been done in 1868 and 1871, to say nothing of antecedent periods, and of the position which has been lost of so many years, and of their growing and accumulated progression, it is well again to turn to the events of 1871.

The completion of the Mont Cenis Tunnel and the Brindisi line at that epoch exercised a great influence, as was well explained before the Parliamentary Committee by Captain (now Sir Henry) Tyler, the chairman at this meeting. Apparently it militated against the through route, because it makes the Suez Canal more effective, and it forms an alternative and duplicate to the through route, enabling a connection to be made with the Euphrates Valley. In reality the Brindisi line in no respect superseded the through route.

It may be well to mention, as a feature of 1871, that Mr. W. Low and Mr. George Thomas carried on an active agitation for a route, which in their publications they styled "The Proposed England and India Railway."

The successive openings of sections of the mutilated Rumelian lines to Salonika, Dede-Aghadj, and Constantinople, as well as the working of the Ruschuk and Varna Railway as a mail route, no less than the completion of the Constantinople (Scutari) and Ismid Railway, gave hopes to the supporters of the through route. The successful pecuniary working of the Smyrna, Magnesia, and Cassaba Railway, and its extension in Asia Minor, was a most favourable incident. Notwithstanding so many obstacles, it seemed as if the Ottoman administration had succeeded in its railway policy, for which it had made so many sacrifices; and if its efforts were successful, the moment seemed to be at hand when it could prosecute with equal effect the extension of its Ismid line and its Asia Minor undertakings. Constantinople has at length become a great railway as well as a steamship centre.

The supporters of Russian interests in England were likewise encouraged by the general progress of their railways, and the opening of the Poti and Tiflis Railway.

All hopes with regard to Turkey in that period of progress were, however, checked by that ill-omened measure, the repudiation, in October, 1876, of the Turkish loans by the decree promulgated by Mahmoud Pasha, the Grand Vizier, more fatal to her credit than the late Russian war, for which it was devised to be a preliminary, and of which it gave serious warning to many. This proceeding, in its re-action, most powerfully affected Russian interests, and has created fears of a similar measure there.

During the late war the question of communication with our Indian empire particularly engaged the attention of many able and patriotic men, and the paper of General Sir Fred. Goldsmid, before the Royal United Service Institution, on June 16th, 1878, most powerfully dealt with the subject. It is entitled, "Our Communications with British India under Possible Contingencies." Captain F. C. Trench also read a valuable paper.

Thus we come to the present period, when we can no longer rely on Turkey helping us, or helping themselves; and when at length we must face the contingency of aiding or re-establishing the credit and resources which have been ruined by our adversaries, while we have stood by to see this done.

Whatever may have been the unjustifiable statements before the war that Turkey was effete and regardless of reform, yet we have seen how, in a desperate struggle, she has brought to bear the fruits of those reforms, not only in the gallant efforts of noble men and women, but in the provision of material applianees, which enabled her to resist long-prepared adversaries, and for providing which the late Sultan, Abdul Aziz, was persistently maligned.

We ean now measure to what a degree of progress Turkey has reached, and how far she has been thrown back. Few, however, know how arduous her career of reform has been, embarrassed by a treacherous foe, and no less dangerous friend. As fast as the country got forward, Russia fomented demonstrations and insurrections in one quarter or another, so that the revenues were wasted in war or military preparations year after year, deficits produced, and the treasury driven to the most onerous engagements towards the loeal banks and other usurers. In drawing up the estimates and budget, the only departments on which economies could be made were on the small requirements of the Ministries of Agriculture, Public Works, and Education, by which all attempts for the moral and material development of the country were starved. I have known the ministers unable to apply five thousand pounds for a purpose of this kind, though earnest and anxious for its accomplishment.

It is indeed wonderful what has been done under such circumstances, with such small means, and with an administration embarrassed in every large town, and every seaport, by consuls, and their dragomans and retainers, aiding and abetting foreign protegées and the subjects of the Porte in resisting the laws and withholding taxes. By such emissaries, acting under the inspiration of the States hostile to Turkey, or for their own corrupt purposes, the attempts to constitute local self-government in the provinces and the cities were impeded, for this evil influence invades the councils, the criminal and civil tribunals, and the municipal bodies, promoting and maintaining jobbery.

The cause of reform, the regeneration of the country, is vital with the statesmen of Turkey. It has been pursued for above a century, against class interests, home prejudices, and foreign intrigues, and more than one Sultan has lost his life in this cause.

Reform in Turkey does not, and cannot, present sudden and successful results; even here it does not, and there, for the reasons already stated, it cannot. English government in England, in Ireland, in Malta, in Jamaica, in India, will show differences and imperfections according to local influences; and, while the same defects are to be

recognised in Turkey, we must not fail to acknowledge the great changes there—changes more than changes always are, improvements and reforms. The people of all sects have been trained to self-government, until they can attempt a parliamentary system, and they want only fair play to enter into the community of free States.

These facts must be dealt with and be fairly considered, if we are to assist in the development of Asia Minor, or if we are to obtain a railway through the Turkish territory. It matters everything whether the people are effete and restrained from progress by the dictates of their religion; whether their Government is destitute of intelligence and integrity; and whether, like Russia, the whole society is so corrupt that its cohesion is endangered, and its early dissolution to be feared.

If such be the condition of affairs, our task is, indeed, a hopeless one; but if it be otherwise, if we have a fair human society, even with ordinary imperfections, we may set ourselves to work with confidence.

This is, indeed, the true condition of Turkey, and all candid inquirers, like Mr. R. H. Lang, with regard to Cyprus, tell us the same facts. The country and the inhabitants seem to be made for our work, and a strong Government, fair play, and above all, time, are what are wanted to secure the restoration of the country.

These are, indeed, the essential conditions for our special subject of this meeting.

At a former period it appeared sufficiently clear, to careful and practical inquirers, that a through railway route to India was necessary to us. At this moment it is not necessary to go into the arguments then applicable, for the question arises how far such or any others are now applicable to this project, in the changed circumstances of Europe and of Turkey.

It is now as clear as it was before that the portion of the railway route passing through France, Germany, or Austria, is liable to interruption by political or military circumstances. This condition, however, disposes of the proposition for carrying our line of communication through Russia, so strongly advocated formerly by those who professed a belief in the absolute power of trading interests to determine peace, in the unaggressive tendency of the Russians as a civilising and tolerant community, in the desire of the Orthodox Church to admit us co-religionists and fellow-worshippers, and in the absolute determination of the Russians, under no circumstances, to assail our Indian empire, were there the smallest possibility of their being able to do so.

There can be no doubt that these latter considerations had a great influence with Indian statesmen and with the late administration, in inducing them to neglect and trifle with the Euphrates Valley Railway. On one side they were dazzled with the Suez Canal as a practical route; on the other, it appeared so feasible, in their eyes, that the Russians, having once established lines of communication to Persia, India, and China, would be most happy to place them at our entire disposal, and be our most humble servants in the matter.

The former objections to the philo-Russian policy have been strongly confirmed by subsequent facts. Whatever the Russians may be able to do in making railways, should their empire be saved from the Communists, Nihilists, and Anarchists bred up by the Russian Government in their late promotion of insurrection, it appears very undesirable for us to rely on such contingencies, or subject ourselves to the evident treachery and perfidy of that barbarous Government.

It must not be lost sight of that the free exercise of our trade can never take place where Russsian administration is introduced. Neither on the European frontier do the Russians allow us free access for our goods, nor on the new frontiers they establish on our own borders in Turkistan. Where the Russian flag flies, there English trade dies.

Setting the Russian railway lines altogether aside, be they made or be they not, we must look to the through route by the Continent. Of this the hostility of continental powers cannot readily deprive us altogether, for it may be looked for that their antagonism will always leave us one course open. It is, indeed, the advantage of the continental system that it gives us a variety of alternative lines leading to the East, and available when storms, snow, interruptions, hostile tariffs, or inimical conditions impede one or more routes.

There are lines by France and Austria, by Germany and Austria, by France and Italy, which provide for breaks. Indeed, having this provision of alternatives, it is our business to continue the undertaking, so that, step by step, and at ulterior stages, we may obtain duplicate and alternative lines, as we have for the telegraphs.

At the present time, our chief difficulty is Rumelia; but we must persevere, and do the best we can under the circumstances. Indeed, we must not delay, but profit by the experience of the past —that melancholy experience of procrastination and neglect. Before the Russian war, we should have had a line through to Ismid, at the least, had the English Government done its duty, and supported that of Turkey in its efforts to make our railways for us. The then petty Government of Servia was allowed to break the through line at Belgrade; and this obstacle, which was not a pecuniary one, could, at least, have been overcome by our Government. As usual, we neglected it, and, as usual, left the Turks to battle for our cause and their own unsupported.

The negotiations at Berlin have provided for the Servian connection of the line, and we must take care that it is effected, as it gives a through line to Constantinople, one to Dede-Aghadj and one to Salonika. The Servians are already talking of putting it off till 1880. This line to Salonika may be made available, even when that to Constantinople cannot be turned to account. We may all look for another Austrian line to Salonika.

A possible line, if the Russians are entangled in Rumelia, is that to the Black Sea, by Chernavoda and Kushenji, through the Dobruja, which the Roumanians will make continuous. Another is that from Bukharest, in Roumania, by Ruschuk to Varna. Should Bulgaria become free from the Russian yoke, the Roumanians will complete the connections across the Danube by bridge or floating bridge, and ensure transit. Upon these subjects much information will be gleaned from the works of Mr. John Trevor Barkley, who was long engaged in the conduct of public works in those countries.

It is to be observed that all the operations here referred to are independent of ourselves, or of our being required to find capital for them or to enter into guarantees. It is, however, necessary to keep a watchful eye and to look after the common interests.

Now we may stop here for a while, and ask ourselves whether the object of promoting a railway to Constantinople can be a trivial one, when we find the railway system of Europe directing itself to that point, and crossing the Danube at several passages. It proves there is a natural trade and transit already, and which will grow as facilities are provided.

Trade by railway transit never stops so long as there is land for it to go on. It only stands still at the shores of the ocean at San Francisco. One of the chief grounds for reliance in going for the whole through route from Constantinople is, that as it is self-feeding and self-providing up to that point, so will it be if carried onward.

So, too, with regard to the eastern terminus at Baghdad. At the time of the Parliamentary Committee 1871-72, the trade of Baghdad was not considerable enough to give support to a railway. From Consul-General Nixon's recent report, it appears that it is altered, that the trade of Baghdad is increasing; and the Consul-General goes to the extent of affirming that the railway will pay.

The cause of this improved condition of Baghdad must be traced to the Suez Canal. This is operating greatly on the trade of Baghdad and the Persian Gulf. Before the canal got into working, the Gulf was one of the most out-of-the-way places, having a long voyage round the Cape to England, and being cut off from the Mediterranean. It was therefore greatly dependent on Bombay, to which it was a feeder.

At present, there is good access to Europe, and, besides that, there is through steam communication by the Canal to Constantinople, Turkey, and the entrepôts of the Mediterranean. This has given a new vigour to Baghdad, political and commercial, and it is possible to transport troops there from Constantinople to check the Arab risings, instead of marching them a long journey or expedition overland.

Then, again, the Suez Canal has strengthened the enterprise of Bombay, so that, from that port and Kurrachee, there is increased interchange with the countries in the Gulf. One of the new regions of production and consumption that are opening to us—and we want them—are these countries, and, apart from any question of a railway, it would be well worth our while to bestow a wise care on their development.

Thus, not only have we the stream of traffic pouring in towards Asia through Constantinople, but, in carrying it on, we know that it will increase the traffic resources of the other terminus on the Gulf.

One reason has been assigned for attending to our self-interests, that it would be worth our while to grow up trade in the Gulf. This, as it may be said, is only general and remote; but there is another reason touching us more directly, and that is, that we have undertaken the protectorate of Asia Minor, and it is by the through railway chiefly that we can advance the condition of Asia Minor and its neighbouring lands. It is one of the keys we have to use to unlock their wealth, and it is the key which will close the financial difficulty.

The assumption of the protectorate of Asia Minor, is indeed to be regarded as a most grave responsibility. We assume a responsibility before the civilised world of Europe and America, and failure will entail more serious loss of power, not only with those nations, but with the lower races of Russia and Asia. This is no time to run such danger, when China has again risen in strength on our northern and north-eastern frontier, threatening not only Russia, as we lightly think, but ourselves. We have, it is true, great chances of success, for we are able to succeed in our task, where the Turks from misfortune and weakness have failed. It is, however, quite possible for us to fail. We may fail from overestimate of our own capacity and want of knowledge of the true situation of the country and the people. We are beginning to learn that the administration, bad as we deem it, is understood by the people, and that they prefer its known evils and defects to supposed improvements which have been proposed. In the government of Asia Minor and Syria in all ages, the existence of the nomad races has to be taken into account, whoever may have had the empire, Assyrians, Egyptians, Persians, Greeks, Romans (old or new), or Turks. It is only a strong government that can keep back the nomads on the eastern frontiers, but it is not noticed that a very powerful administration is required to keep down the nomads, who, with their herds, infiltrate among the agricultural populations, claiming olden rights of pasturage. The Koords, who in Kurdistan are strong enough to plunder and murder the Armenians, as herdsmen, wander into the plains in the neighbourhood of Smyrna and the Mediterranean shores. The herdsmen, wherever they find weakness, are lawless.

At this moment the Ottoman Porte has to reckon with the Koords to the East, the Arabs of the Baghdad Viceroyalty, the mountaineers of Little Armenia, and the Arabs of the South. Undoubtedly the help of the strong power of England will keep these down, as they were kept in the best times of Rome. Kept down they must be, if the husbandman is to ply his work, and the carrier move safely on the roads. In fact, the question of police is, in this matter, most concerned, and it is here the railway will most effectually come to our aid.

The really main point in the whole subject of administration is the farming of the tithes or taxation. By no invention of the Turks, but by inheritance, they have become involved in this most ancient system of taxation, long known to us in India, and, even in the time of many living, in existence in England, the payment of tithes or taxes in kind. With this is closely connected what in old France was called *corvée*, and now *prestation*—forced labour; with us known as a labour rate.

In countries without money, in Egypt, in the Roman empire, in France or England in the Middle Ages, in India, and now in the Hellenic kingdom and Turkey, it is most convenient to the husbandman to pay in kind, and, besides, his payment is adjusted to his crops. His tax is taken on the spot—none when there is a dearth, and only

according to his abundance if he has been blessed with plenty.

To a Government, however, the system is inconvenient and dangerous. The Government thereby receives grain scattered all over the country. It cannot clothe its soldiers therewith, and can only feed them on the fields of production. The Government is therefore obliged to sell, or what is called farm, the taxes, and this has two evils; the first and a serious one is that the government can borrow on subsequent gross receipts, and anticipate revenue, thereby coming under obligations to the tithe farmers, and being more in their clutches; the second, and worst, aggravated by the former, is that the Government is obliged to abnegate a portion of its own power and prerogative and transfer them to the tithe farmers, or *publicani*, and their servants.

For a Government like Turkey formerly, or China, only receiving tribute from its provinces, and leaving the administration to local boards, the system, financially, was not so bad, but for the subjects none the better.

Theoretically, or by law, the subject was always protected against any exaction of the tithe farmer, who was made liable to pains and penalties. Practically, the tithe farmer was allowed immunity, and the Government was altogether powerless to help the oppressed.

The tithe farmer can always put the cultivator to trouble by causing delay in collecting the tithe, and has many engines of annoyance if the cultivator will not give something more. The village head is always favoured in the apportionment, and, being muzzled, cannot be employed against the oppressor.

The oppressed cultivator can appeal at the market town of the hundred, but the authority there, being afraid to help him, dallies with the matter. He can then appeal to the county town, and, after spending much time there, may get a decision in his favour, which is so much the worse for him, as the tithe farmer appeals to the Governor-General of the province, and keeps him standing about in the city. If the Governor-General is a just man, it is a bad day for him, and a bad day for the complainant, if judgment is given for the latter. The tithe farmer, who has his agents in the capital, besets the Minister of Finance and the Government, but by that time the complainant is overwhelmed by the expenses and absence from his farm, and is irretrievably ruined. So is the Governor-General or Governor who decides against the tithe farmers, for though his conduct is approved by the Government, the corporation of tithe farmers decline to have anything to do with a province in which such a governor is placed. The result was that, in France, such a governor was promoted to some petty or honorary office about the person of the King, or made a Knight of St. Michael or the Holy Ghost; and in Turkey he was called to Constantinople to get on as he might, and to receive high praise as his consolation.

The injury to the Government from tithe farming is greater than to the subject. The latter prefers payment in kind, and looks on its abuses with toleration, but the system of administration is demoralised, and an irresponsible administration created within the administration. Then, too, the tithe farmers and their retainers are always looked upon with hostility and abhorrence by the people. Of this a very good type is afforded by the Publican of the Gospels. In many parts of Turkey the tithe farmers have belonged to the lower classes, being Greeks and Armenians, with Albanian brigands as their police; and upon the Mussulmans they inflicted greater oppressions than on the Christians, the Mussulmans being the more industrious and the chief cultivators, and the Christians of late years having foreign or influential protectors.

So powerful is such an *imperium in imperio*, that occasionally they have been enabled to commit the greatest atrocities with impunity. When they had made advances and bought tithes in advance, a bad harvest would leave the tithe-farmers in a loss, and they made good their losses out of the population, seizing even the ploughs and working bullocks and seed corn, and throwing the land out of cultivation in the moment of public danger. In Magna Charta it was found necessary to put in a provision against this offence.

It is no wonder that the French Revolution happened; it is only a wonder that it did not happen years before. The wonder is that provinces such as Asia Minor and Syria, which have always been under this system, should ever have flourished. The fact is, with a strong Government keeping back the nomads, and enabled to enforce the law, and with a population thereby enabled to maintain culture and keep the watercourses in order, such is the fertility and abundance of those countries, that they were enabled to raise vast crops and furnish great wealth to their Government.

What was the real condition of the working population, free and slave, in those times, under the Roman or Byzantine Empire, is another story. We know that they suffered fearfully from pestilence, earthquakes, and famine, and there is no reason to suppose that they were other than they have been in the good and bad times of Turkish rule.

While it is quite certain that Turkey can never flourish with tithe farming, it is not so easy to abolish it without substituting for it other evils. The Turkish Government, earnestly desirous of effecting the abolition, began the experiment after the Crimean War in Europe, intending to apply it afterwards in Asia. They substituted for the tithe in kind a money payment, under what is known as the village system in India. Each village was allowed to commute its tithes for a money payment at the rate of the average of the seven previous years, and to cultivate as much as it could. For a year or two the plan worked well, and there was an increase of crops, but long before the end of the term the population was in great misery and distress, and earnest for the abolition of the new plan, and the restoration of the old abuses, to which the Government had to yield.

The reason was a simple one. The agricultural classes, as we know in India, are improvident, and are always in debt to the shopkeepers of the towns. To pay the tithe the growers required further supplies of money, and thus became the greater prey to the local usurers, finding themselves growing poorer and poorer.

The Turkish Government know this state of affairs to their sorrow, and hence, in accepting in

principle the abolition of the tithe proposed as a reform by the British Government, the Porte stipulate that it shall be applied experimentally in some districts.

This is the rational course. In many provinces there is no money for paying taxes, and no local or outside market for surplus corn. If the corn can only be carried to markets which do not want it, it cannot be sold, and to carry it to any distance heavy rates of transport must be paid. Grain can only occasionally be sold abroad when the price is very high outside, and thus the profit goes not to the growers but to the tithe farmer and the shopkeeper, who can hold stock.

Having made what might appear to be a digression, we are thereby brought to a point where, on this important question of the abolition of tithe farming, of the efficient action of the protectorate, and of the reinvigoration of the Ottoman State, we have to provide money for the purpose.

Corn at Angora, Konieh, Kutahiyeh, or Mosul, is the same commodity as it is at Constantinople, Genoa, Marseilles, or London, but the price is very different. We have, in fact, the same matter to deal with as what is now more familiar to us—the wheat trade of Upper India. We never got wheat from there until we could carry it away cheaply by railway to be shipped through the Suez Canal.*

We must do the like again, we must carry railways through Asia Minor and Syria, and they will of themselves stimulate branch and port lines. We must give a money price to the grain of Konieh and Kaisariyeh, so that money shall be given for the surplus growth beyond the food of the local populations, and this will supply the fund for the payment of the commuted money tax. The ultimate result will be that the railways will raise local prices and increase the general resources of the population, and the funds of the general and communal treasuries. These results of development have been powerfully impressed upon me by a great practical authority, General Sir George Balfour, M.P.

No other measure but the through railway will effect this, and the through railway will likewise accomplish other purposes scarcely less in importance. In one respect the railway, more than the telegraph or the telephone, is the greatest political and military engine or apparatus we possess, beyond a gun of the heaviest calibre, or a fleet of ironclads of the newest dimensions. To Asia Minor and Syria the application of this instrument of government is indispensable, and will be successful. It at once gives efficiency to the local police in countries with sparse populations; policemen are sent out and prisoners brought back, and the requisite force is despatched to resist brigandage and gang robbery.

It is by this means alone that a limited force, at moderate expense, can be applied to resist and prevent the inroads of the nomads. The profit from this would be threefold—first, in saving the maintenance of troops; secondly, in saving the waste of human life and produce by the marauders; and, third, in allowing a greater breadth of land to be cultivated.

* Mr. C. E. Austin, C.E., who has had many years' experience in Russia and Turkey, has just stated the results of his knowledge in an elaborate work on the "Undeveloped Resources of Turkey in Asia," which contains a mass of valuable facts. I say this without adopting all his opinions.

A further great economical advantage will be in preserving the country against attacks from the semi-civilised Governments of Russia and of Persia, the menace or the perpetration of which has so greatly impeded the progress of the country, protecting disorder, taking away its agricultural population for military service, causing the deaths of many, and the mutilation of others. Protection for Asia Minor and Syria is the more essential now, as the power which has caused the greatest disorder and misery to the populations of Asia, has lately been allowed to occupy more fortresses, threatening more seriously the tranquility of the country.

People are very apt to look upon railways as a mere variety of roads, or as an investment for shareholders, which is to return so much per cent., and yet roads in the hands of the Romans and ourselves have been looked upon as a great foundation of civilisation. Some people still look back to roads. Some people believe that the first thing to be done in Turkey is to make roads. We have in the railway a greater and more efficient instrument than the road, and we may as well resort to bows and arrows as to roads in these days. Undoubtedly railways have done for India what several grand trunk-roads and five thousand miles of irrigation and canalisation, good in themselves, never could have done. Roads, canals, and even railways, will follow in the wake of a railway.

A suitable trunk railway through Asia Minor and Syria, apart from its returns for transport or traffic, will, it has been shown, yield a large return to the governing power in creating a money value for produce, and in providing money taxes, emancipating the country from the curse of tithe-farming; it will save money in gendarmery and soldiery; it will prevent waste of soil, and enable a far greater breadth of soil to be tilled, and in every way increase produce, economise resources, and augment Government revenue. Besides this, such a line will return traffic, which within a comparatively short time will yield an adequate revenue.

We now come to the point, What is to be the nature of such line, can it be substituted by a Euphrates fragment, and what route shall it follow? Upon this latter point much has been written, and various plans have been proposed by very able men, each of which possesses its own merits, but it appears to me that we have not at this time to entangle ourselves in such matters. It should rather suffice that we know there are many practical plans opening up various ports and trade routes, but which we can hereafter best deal with (right or left bank). Tigris, Euphrates, Palmyra, Haiffa, Tripoli, Suedieh, Skanderoon, Ayas, and all the various projects that this agitation has produced.

It is, indeed, a great temptation to deal with some of these individual projects, such are those of such eminent authorities as Captain R. F. Burton and Mr. W. Gifford Palgrave.

Not only do questions of commercial traffic affect the choice of line, but also what are precedent, because they are more material, military considerations. Commercial accommodation can better follow military requirements than the military can the commercial. The military relations have been carefully and ably dealt with more than once by Captain (now Sir Henry)

Tyler, in his evidence before the Select Committee, and in various writings and reports.

We must now make up our minds to the main plan, and what we are to go for, whether the usual railway, or what is called a cheap railway, or a narrow gauge railway.

Upon the question of gauge, it may be said that a narrow gauge is chiefly put forward as a means of providing a very small capital, in the first instance, and of economising resources. Otherwise, it is certain that in Europe, in America, and in India, the question is settled, and that no practical man will propose a narrow gauge for a main line if he can get the usual gauge. If the railway is to be a continuation from Constantinople, it must be of the European gauge, because the trains will ultimately be carried across the Bosphorus, either by a bridge, which is quite practicable, or by a floating ferry.

For a line passing through hot countries, there are very strong objections to the use of a narrow gauge or such expedients, because, as has been well pointed out by a competent authority, Mr. E. B. Eastwick, C.B., they are intolerable to Europeans, particularly during long day and night journeys. They have been introduced in India, and the experience is not favourable. The narrow is the gauge of the South of India Railway, and Mr. Eastwick considers that in the hot weather it amounts to a negation of the use of the line by Europeans. The same is the case on the line between Lahore and Multan. The heat strikes through the roof, so as to be most dangerous, and the whole carriage gets heated to fever heat. Mr. Eastwick says that the speed of the narrow gauge, whatever falsehood may be told, does not exceed ten miles an hour. The trains are always breaking down, when the wretched passengers are exposed to a fiery death for two or three hours. The Hindus get out, walk a mile or two to the nearest town, and take their food. Besides, as Mr. Eastwick observes, the narrow gauge is next to useless for military purposes, and the transport of artillery.

There is no financial necessity for resorting to any temporary expedients of a narrow gauge, for the undertaking requires efficiency, and can yield remunerative returns to pay for them.

So far as the mutilating of the undertaking, by making the Euphrates portion alone, depends on financial expediency, there is no necessity for it and no justification, because the Asia Minor section is that which will, for the reasons already shown, pay best in the beginning. There are, however, as here shown, other reasons besides those of finance, and they preponderate in favour of carrying out the whole undertaking. I agree with Lord Waveney, Sir Frederick Goldsmid, and Colonel E. Gordon, R.E., that at this period it is indifferent what route is put forward.

We may conceive, as a general line, one starting from Constantinople—Skutari, passing through Angora, Sivas, Diarbekir, and Mosul, to Baghdad, being joined by a line starting from Skanderoon, and passing through Aleppo.

Such a line is here put down merely as a proposition, for the purpose of bringing the subject under consideration. There are, for instance, objections to the very line here sketched; but, undoubtedly, if we could get this line, or something like it, it would effect our purposes. For my own part, the question of individual lines is of far less importance at this time than we are apt to believe; because, if the line thus proposed were carried out, nearly every other plan would be also carried out, because they meet practical wants, and resources would then have been provided for their accomplishment.

When we come to the consideration of local lines in Turkey, then many of the projects which have put forward as main lines must be dealt with as local lines, and they will become alternative main lines.

If Mesapotamia, for instance, is still what it was for thousands of years, and what those who know it believe it can be brought to be, then no one line on either bank of the *doab* will be adequate. Produce will not afford to pay to cross one or two troublesome rivers to meet a railway station a hundred miles off. A trunk line is a very valuable thing, but it can neither receive food nor nourish beyond a limited distance, while its wholesome influence stimulates the creation of feeders.

Adopting as a plan for consideration the one before us, which will do for the purpose, we may consider what it will effect. It will carry passengers and traffic from Europe eastward and throughout the route, at the same time stimulating local production. It will enable the European forces of Turkey to operate freely on the exposed frontier, and it gives the opportunity for an Austrian force to be brought to bear. It provides the means for an English European force to be brought from the Mediterranean, and an Indian force from the Persian Gulf. It allows the emigrants of Western Europe, artisans and others from Germany, Austria, and the Danube, to carry their skill and labour into Asiatic Turkey. It is to the several results of such emigration that the advance of Roumania is greatly due, and by which that of Servia, Bulgaria, and Rumelia will be promoted.

We must not leave out of sight what is of much importance, the reaction of the through route in stimulating and strengthening Constantinople itself, Rumelia, Bulgaria, Servia, and Bosnia. The same effect will be produced in Greece, and the islands, in Italy, in France, and also in Odessa and Southern Russia.

To the through route subsidiary and alternative communications can be made from Marseilles, Brindisi, and Salonika.

One of the most distinguished practical authorities on India, a member of the Council, has called my attention to the consideration of the danger of interference with the railway from wild tribes, and this idea is one rather suggested by the telegraph, which is liable to such interferences, but the railway is better able to defend itself. No case occurs to me, in the old or new world, of a railway being stopped by wild tribes, but wild tribes have been effectually stopped by railways. In the small portions of the through route where there could be risk from wild tribes, the matter would have been settled before the opening of the line, as new relations are established with these tribes which effectually dispose of the difficulty. Their employment as carriers, guards, and in various ways, and their share in the new wealth, settle the relations of most of them with the railway, while each station becomes a police station, and the telegraph and the train can bring down summary treatment on marauders.

The section through Asia Minor will effect the objects that have been already referred to. At the same time it will ultimately have connection with the coast, at all events, with Smyrna, and thus increase the commercial and military capabilities of the undertaking.

Whatever ports may be hereafter built, we have two available under cover of Cyprus, Skanderoon, and Ayas, opposite to the north. Ayas has been more than once referred to in the *Journal* by myself, in 1871 (Vol. xx. p. 27), and again on the 30th of August last (Vol. xxvi. p. 87). As the merits of these and other ports are under the personal examination of Captain Cameron, R.N., the African explorer, we shall obtain further information. Mr. J. L. Haddan, late engineer to the Ottoman Government, has paid special attention to Ayas, and he has written on this, as on many subjects connected with the engineering of the country, and on his own plans, for what he has denominated a pioneer railway.

The Euphrates or Tigris section will serve as a portion of the through route and as a local section, developing Smyrna and Mesopotamia. Whatever the terminus on the Mediterranean, that terminus will provide an efficient seaport and a commercial entrepôt. That section will also serve to let in, should occasion arise, European contingents from the West and Indian from the South, to put down local rebellion and foreign aggression. With these questions Mr. S. J. Eldridge, H.M. Consul-General in Syria, has very ably dealt.

The continuation of the railway from Baghdad to Bussorah, or to India, is an ulterior affair, for, as Consul-General Nixon has shown in his last report on the trade of Baghdad, the steamers of the Euphrates River Company run from Baghdad to Bussorah in three days, and from Bussorah to Kurrachee, a distance of 1,574 miles, in six days. From Baghdad to Skanderoon, the Consul-General estimates at 60 hours. He believes from the growth of the Baghdad trade that the railway will pay.

This subject of the through route to India has seldom been brought forward by others or myself but what it has been treated also in reference to our connection with Persia, notably so on the occasion of the paper read before the Indian Section of the Society of Arts, by Sir Frederick Goldsmid, on 20th April, 1877, under the title of "The Existing and Possible Commercial Communications between Persia and India." This brought up the question of the entrance into Persia by the Karoon river. Although at an angle to the through route, this is, in fact, a direct access from England to Persia, and preferable to the northern route through Russia. This has not been looked after by our Government, and the concession is in the hands of a French physician. If this plan be carried out by him or others, it must provide a feeder for the through route. Thus, one large matter at stake is the present and the developed trade of Persia.*

Looking to the influence which Indian enterprise has already exercised on the trade of the Persian Gulf, we must look to its further effect when it can be made to penetrate above Baghdad. It is by the careful enumeration of resources, present and prospective, that we shall best be able to estimate the nature of the undertaking we have to carry out, and in the same way as it is not to be regarded as only military or political, so it is not to be regarded as chiefly commercial.

Undoubtedly, so far as India is concerned, the advantages of the through route, moral and material, will be very great, but although we are justified in looking at it to a great degree as effecting our Indian empire, it does more. Since the opening of the Suez Canal, our connection with Australia, from this side, has acquired more importance. The through route, without being, at the present time, essential for Australia and New Zealand, is of material value. The working of the Pacific Railway and of a steam service from San Francisco to Australia creates a rivalry with the transit by the Suez Canal and the Cape, and makes the value of time and quick communication to the Australians still more sensible.

Although Western Australia is still backward, Australian settlement is spreading to the north. Queensland touches the north shores. South Australia is advancing its occupation in that direction. Although we cannot exactly forsee, we must allow for a large expansion of trade in Northern and Western Australia and New Guinea.

Thus Australia and New Zealand have a distinct interest in the through route, because they have military and political objects to regard, as well as those of transit. Since the Crimean War the Russian naval ports have been pushed one thousand miles south to a sea always open in winter. What this means the Australians can understand, when the Russians, while making speeches about peace, are preparing privateers in the American ports of the Pacific and Atlantic to attack English and Australian merchantmen; Sydney and Melbourne have been compelled to look to their home defences.

The contributions of the Australian colonies and New Zealand to postal and telegraph services are a dead expenditure, but to a through railway route they need not extend further than a temporary advance.

It is because the Suez Canal transit is so valuable to us, to India, and to our Australian communities, and can be so easily closed, that it is absolutely necessary to have an alternative route. We can no longer expect that the Pasha of Egypt will be able to carry out his scheme for a railway to Upper Egypt and Berenice on the Red Sea, nor would that, perhaps, be safe from the dangers affecting the Suez Canal. We are, therefore, driven to support the through route.

If we were to go back 20 years, or only 10 years, and examine the development of trade in the East, as manifested simply by the extension of steam navigation, we should find that it is vast. going on, and growing. Throughout China and Australasia, an active competition by steamers of various flags is carried on, and thereby a great stimulus is applied to commerce. The encouragement, therefore, for engaging in the through route is greater, and the risk is less. Many may think the subject still so new that it is out of place to talk of what might have been done ten or twenty years back, but the author of an able article in *Blackwood* for October, on "The New Routes to India," himself makes the review in reference to an article

* A discussion on the Karoon, by Mr. T. K. Lynch and myself, will be found in the *Journal of the Society of Arts*, vol. xxv., p. 530. See also the appendix to this paper.

he had before written in *Blackwood* of June, 1856, entitled, "Speculations of the Future." It is the most melancholy side of the history of practical measures, to find how the enjoyment of their benefits has been needlessly delayed, to the great detriment of society.

Our position is also changed by the occupation of Cyprus, and the claims to the protectorate of Asiatic Turkey. We are now brought directly on the scene from which we were before remote.

Cyprus is so situated, as it is acknowledged, that it can guard the Mediterranean terminus of the through route, and, if it had the railway open to Skanderoon, or some neighbouring port, it could send troops for any necessary purpose to Syria, or to Asia Minor.

Those who have carefully studied Cyprus must concur in the judgment of Mr. R. Hamilton Long, that it is a valuable possession, and can be made to pay. When the troops and civilians come to be properly housed and provided, there is no reason why they should be scourged with fever there more than elsewhere. One great cause of the fever has been alleged to be the breaking up of the ground, and this is according to my experience.

Never was a greater injustice done to such an able and patriotic public servant as Sir Garnett Wolseley, as to send him out so unprovided. In an island governed by Turkish institutions he had not with him a man acquainted with those institutions, or able to translate his proclamation into Turkish. For what has happened he is in no degree to blame, and for the way in which he has redeemed us from the difficulties in which he was plunged, he deserves the highest credit. Few men have done what he has in repairing the errors of others, and in setting matters straight. In his hands, and with time, the island will undoubtedly pay.

What is the exact part Cyprus will play it is not easy to lay down. Instead of being a dependency of Beiroot it will most likely become a great commercial entrepôt, and will fill the place which Smyrna once held; and assuredly, if the through route is carried out, a sufficient harbour will be made, it will be constituted a port of call, and, by local steam to and fro, it will supply Beiroot, Skanderoon, and the Euphrates Valley, Adalia and Smyrna, and take part in the trade of the great Archipelago.

Here, again, the through railway is an essential part of our system; without it Cyprus will be isolated. More strongly does this necessity show itself as to our protectorate of Asia Minor and Syria. Apart from political and military purposes, that protectorate is to be made effective.

First. By our co-operation in maintaining the police of those regions.

Second. By assistance in gradually abolishing tithe and tax-farming, as already laid down.

Third. By co-operation in laying out and in carrying out public works.

Fourth. By giving the same assistance for making known and developing the mineral resources.

Under the latter head, to take one district alone, the railway district of Western Asia Minor, so far as I know, there are the elements for a large production of local coal, for smelting iron of the best quality, for working emery, copper, lead and silver, and marble. It has long been my opinion—but I could never succeed in obtaining a practical examination—that gold is still to be worked in those districts anciently reputed to yield gold.

What is wanted chiefly is to abolish the system of mining administration imitated from the French, and to shut up the Department of Mines, placing the working of mines at least on as free a footing as in this country, if not making it absolutely free. Of course, right of property must be given in a discovery on registration and payment of a nominal fee, as is done in the Duchy of Cornwall for tin bounds, and as is carried out still more largely in South America.

It may be said that one element of agriculture is wanting, for wooden ploughs and shovels mark its condition in many places; nor can iron implements be effectively used if they could be paid for, when in some districts you may go a hundred miles without finding a blacksmith. The shoeing smith on the roads only nails on a ready-made horse-shoe. Heavy machinery cannot be carried on camel-back, and could not be repaired unless European workmen were maintained. European artisans do not go where there is no work. All over Asia Minor there are valleys called "Ironmen's or Ironworkers' Valley," where anciently smelters worked, and where now the gipsies ply their small furnaces. There is no want of natural resources, but people thinly scattered, with a poor return for their export produce, and with no money, cannot turn them to account.

In a discussion, every point of which is connected, the topic we are upon brings under notice one question, how far emigration is absolutely necessary. The country, as we learn, has greatly suffered by the war, and the Turks, the agricultural workers, have been much reduced. Emigration, no doubt, whether of the exiles, who have escaped from the Bulgarian murderers, and are denied return to their properties by the Russian accessories, or whether of foreigners, will, undoubtedly, increase the resources of the countries. Whether it takes place or no, or to a greater or less extent, at all events, we have one safe mode of increasing the resources of the countries, and that is to enable the present population, by better appliances, to secure greater produce from the soil. Foreigners will flock in, and the Turks, who are hardworking, intelligent, and ingenious, will learn quickly from them, and so will the Armenians, who possess the same qualities.

Looking upon the through railway as essential to our interests, and as a remunerative undertaking, it does not appear to me objectionable for us to participate in it by taking shares or by guarantee. A guarantee is the simpler course, but there is great indisposition against it by the authorities here. There is, however, another plan which I bring forward for the consideration of those interested.

It may be taken that the ultimate outlay will be represented by a loan, of bonds or debentures to be discharged, principal and interest from the returns of the railway, and other resources of the Turkish Government. One resource fairly to be apportioned to this service is the whole or a portion of the increase of tithes and other land taxes, Excise and Customs dues, beyond the present returns from the provinces concerned. This is without consideration of any land or labour grant. Whether the railway yields a large return or no, or until it

does, at all events there will be a great increase of fiscal revenue, and this not from the date of the opening of any section of the railway, but from the very commencement of the works, irrespective even of the opening of the railway for traffic. It is the nature of such operations that they shall give a great stimulus to the development of agriculture and all industrial enterprise. The effect of the outlay of capital will only last for a few years of itself, but it becomes permanent by the operations of the railway or other similar work of the class commonly called reproductive.

Assuming the issue of an Asia Minor and Syria Railway Loan, my proposition is to make gradual advances by Public Works Commissions, general or special, of Exchequer or Treasury Bills. The proceeds of such securities would be applied successively to the execution of portions of the railway, and as such portions were opened and yielded return, and as there was an accruing increase of Turkish public revenue, so would the bonds of the railway loan be sold, and the advances of our Government be redeemed, without any very considerable outlay, and without any material risk.

If the money were attempted to be at first obtained by any Turkish direct guarantee, what with the jobbery of financiers and contractors, and what with the mistrust of the public, the securities could not be floated except at a large discount, and a return of ten per cent., exclusive of a sinking fund for redeeming the depreciated bonds at par. This would impose a very heavy burthen on the undertaking, and on the Turkish treasury.

A railway bond, secured on the proceeds of a railway under English government inspectors, and on funds in English custody, could be placed, on very fair terms, in Eastern and Western Europe, where there is a want of such securities. It would not be regarded as an English guaranteed stock, but a bond of the class of good French and German railways. The Turkish treasury would ultimately receive all proceeds beyond the sum yearly allotted for the payment of the interest and sinking fund of the railway bonds. No arrangement has yet been proposed but that of an English guarantee, which is calculated to raise the funds on such good terms, and to accomplish all the objects required. With regard to the risk to be taken by the English Exchequer, it might be divided with that of India, and with the treasuries of Australia and New Zealand. It would be well worth while for the latter treasuries to guarantee the Imperial Exchequer to the extent of a sum of one million sterling for the purpose of securing such an object as a through railway.

Were it desirable to have an international combination, it might be possible to arrange for a French and Austrian participation. If the plan and concessions of General Klapka are carried, then, under arrangement with the Austria-Hungarian Government, the extent of the English share might be lessened. The simplest way would be advances from England from time to time, limited in extent by Parliament.

Although the operation here proposed is not the same as the purchase of the Suez Canal shares, and is indeed much more limited, it has the example of the Suez Canal case as one of a financial transaction carried on outside the bounds of our territory, and less burthensome than advances or guarantees to Canada or the West Indian islands.

Further detail is not entered on here, for detail depends on the adoption of some such principle. With regard to the organisations to be adopted for carrying on the works, if the funds were chiefly obtained primarily from foreign sources, the Turkish Government could hardly require the supreme control of the disbursement of the money. There would be equal danger of the Turkish administration, or the jobbing of English or German speculators*. It is to be determined whether the works shall be assigned to a commission, a construction company, or a working company, which should also take charge of the construction. It may be a convenient mode to form a working company, which should provide the engines, stock, workshops, machinery, and stores, and which would consequently find a considerable portion of the capital. The new constitution of the East India Railway Company, as a working company, gives an example to the English public of such a company.

If the through route is to be used as a convenience for financiers, directors, and contractors, then there will be the same waste of means which has hitherto taken place in Turkey, and which is a great cause of the present unfavourable situation.

That railways in Turkey can pay is proved by the Smyrna, Cassaba, and Alasshar Railway in Asia Minor, which, notwithstanding its being heavily weighted by financing, meets its guarantee. It is proved likewise by the Smyrna and Aidin Railway, still more grievously burdened, and which yields a large net revenue. This, even in its present undeveloped state would give a fair dividend on the real money cost of the line. Had the Varna and Ruschuk Railway been free from the financiers, it would have paid.

There is, therefore, from these examples, a fair prospect for much of the through railway, and likewise for the construction of local railways in Turkey, properly selected. As the country is thinly peopled, carrying power is of the more necessity, and it is very questionable whether, except for temporary purposes, narrow gauge railways should be at all encouraged in Asia Minor and Syria, but the date should be anticipated when a general railway system or regular connections would be established.

In proposing the financial measures just laid down for the purposes of the Asia Minor protectorate, of course it is desirable they should be applied to local lines, and a very inconsiderable sum would be sufficient in the beginning to do very much good.

The extension of the Smyrna and Cassaba Railway to the coal-fields and the interior should be at once begun. The directors have such measures in their contemplation, and will in all probability carry on the work with their own resources, but if a temporary advance of £50,000 or £100,000 would promote the undertaking, then it should be made.

Sir Edmund Hornby, who for many years held a high position in Turkey, and has written much,

* Mr. J. C. McCoan, in the last "Fraser's Magazine," has an article dealing very severely with the conduct of public works by the Turkish departments and the English companies.

formerly and of late, on Turkish subjects, has particularly called my attention to the local lines.

The extension of the Smyrna and Aidin Railway in the Cayster Valley, which is populous and fertile, might be encouraged, sufficient guarantees being required for the proper conduct of the works and the management of the traffic on the branch and main line.

The through route would be an extension of the Skutari and Ismid Railway, and any line from Skanderoon and Aleppo, and from Baghdad into the interior, would be a local line. A good beginning might, therefore, be made with local railways which would be a test, and would show of what they are capable. Very good experience might be got from the conduct of the Cassaba extensions, and of the Smyrna, Aidin, and Cayster Valley extension.

To some who consider the work of the through railway a wild undertaking, in a country without means of carrying them out, it may be observed that there is no want of natives and Europeans, who have been trained on the railways in Europe and Asia, to act as contractors, sub-contractors, gangers, navvies, artisans, engineers, timekeepers, clerks, &c., men conversant with the languages, ways, and resources of the country. In Turkey, there is some railway work of very good character. The effect of carrying on such undertakings has been proved by experience, in Turkey and elsewhere, to be the education of men, who are enabled independently to assist in the development of the country. The railways in Turkey have supplied it with the knowledge of many new arts, and with artisans, many of whom set up in business, or enable, by their co-operation, new branches of enterprise to be carried on.

Another part of the education of the people would be the adoption of judicious measures for placing some portion of the railway bonds locally. Notwithstanding the abuse lavished on the Turks, they have been saving of late years and accumulating, a sufficient proof of which is the large amount locally held in the General Debt. The people subscribed a considerable amount of the Smyrna and Aidin guaranteed 6 per cent. shares. It may be estimated, such is the desire to have a good security for savings, that ultimately, 5 per cent. bonds could be largely placed.

Among many to whom I have been under obligations for assistance and advice in drawing up this paper, but who need not be held responsible for my opinions, which, in many cases, openly differ from theirs, are—Mr. W. P. Andrew; Colonel E. Gordon, R.E., formerly acting president of the Department of Public Works in Turkey; General Sir George Balfour, M.P.; General Sir Frederick Goldsmid; Sir H. Tyler; Mr. T. W. Rumball, Consulting Engineer Ismid Railway; Captain Stab, Assistant Cotton Commissioner and Land Commissioner in Asia Minor; Mr. C. E. Austin, Consulting Engineer of the Smyrna and Cassaba Railway; Sir Edmund Hornby, formerly Judge of the Supreme Circular Court at Constantinople; General Sir Arnold Kemball; General Sir Henry Green, hon. secretary of the Asia Minor Railway Committee at Stafford-house; Mr. James Landon, late Concessionnaire of the Railway from Constantinople to Ismidt and Sivas; Mr. T. F. Reade, H.M. Consul at Smyrna; Mr. R. P. Harding, Director of the Smyrna and Cassaba Railway; and Mr. F. Humann, late engineer of the Prince of Samos.

Appendix A.

To save space in the paper, there is appended here the circular of the Asia Minor Railway Committee to the Chambers of Commerce.

Constantinople, Mediterranean, and Persian Gulf Railway.

The only link now wanting for rapid intercourse with Constantinople is an unfinished portion of railway through Servia. It is stated that, by recent negotiations between Austria and Servia, this gap will be filled up in three years, and then railway communication will be complete and continuous between Calais and Constantinople—about 1,800 miles—a journey of three to four days only.

The object of the memorial to Lord Beaconsfield, which accompanies this, is to solicit the Government—not themselves to undertake—but to assist, by negotiation and by a moderate guarantee, in the promotion, as a national work, of the continuation of the existing railway route towards India, by the formation of a line from Constantinople, *viâ* Diarbekir and along the left bank of the Tigris, to Bagdad and the Persian Gulf, connected with the Mediterranean and Alexandretta by a line from near Mosul *viâ* Aleppo. When the railway is thus completed from Constantinople to the Persian Gulf (a second distance of about 1,800 miles), nearly three-fourths of the journey to India will be accomplished by land, and in a much shorter time than is possible by any other route.

The Indian Railways will ultimately be extended westward to meet this line; but even at present, the voyage to Bussorah, from the harbour and railway terminus of Kurrachee in India, occupies only from 84 to 87 hours.

The whole of the railway lines at present proposed will be in Asiatic Turkey (where, in the words of Consul Skene), "vast internal resources exist without manufactures." Consequently, our trade with that country, which is already large, will be greatly developed; and it is anticipated that the undertaking will ultimately yield a good return to the company supplying the capital required for construction and working. But as the security of Asiatic Turkey may be said now to depend upon the protectorate of England being constantly maintained, it is considered necessary, in order to guard against loss from possible political changes, to obtain from the British Government a guarantee of a moderate rate of interest on that capital; and that the cost of preliminary surveys, if not defrayed by the Government, should be included in the outlay to be guaranteed. Such a guarantee may be reasonably asked from Government, as the railways will assist materially in the defence and prosperity not only of the country which Britain has undertaken to protect, but also of the Indian Empire.

It is expected that the Ottoman Government will give gratuitously all the lands necessary for the railway, with all other privileges.

The port of Alexandretta (Scanderoon), by means of which the sea access by the Mediterranean to the proposed main line would be maintained, is unhealthy only from neglect. Consul Skene reported in 1875, "If the Porte were to lay out £2,000 on the drainage of the marsh at Alexandretta, a commercial town would certainly rise there as rapidly as Beyrout did after the Egyptian occupation of Syria, the harbour of Alexandretta being much better than that of Beyrout."

The projected line (of which the first section to Ismidt —70 miles—is already constructed and in actual operation) proceeds from Constantinople, and completes a

through land route, at once from Calais to the Persian Gulf, and ultimately to Kurrachee and all parts of India. It will pass through the heart of and will develop a rich and populous country, while the scheme, as a through line, will prevent a great unnecessary expenditure of capital upon partial and unconnected projects, and, from its central position, it is capable of accommodating future needs, as they arise, by means of lateral branches.

The signature of the memorial to Lord Beaconsfield will involve no pecuniary liability, and if influentially signed it will encourage the Government to do all that is required for carrying forward a work which has become necessary for the maintenance and development of British Imperial interests.

Sutherland, President.
W. P. Andrew, Chairman.
A. B. Kemball, Lt.-Genl., R.A., Vice-Chairman.
Henry Green, Major-Genl., Henry Wright, } Hon. Secretaries.

Stafford-house, London,
6th August, 1878.

Appendix B.

From the *Jewish Chronicle* I take advantage of the following explanation of a local route in reference to that and to the Jaffa Railway:—

Under Carmel, in the hollow of the bay, lies the town of Haifa, the ancient Hephah of the Talmud, "the Haven," famous for its Hilzon fishery, whence the Tyrian purple was derived. The town is walled, and has a population of 4,000, of whom 1,000 are Jews. It has a Jewish cemetery, and from the middle ages down has been a favourite resort of the Hebrews. The Carmel Bay is even now a roadstead which good sized vessels can visit throughout the winter. At a small expense it might be converted into a valuable harbour. A mole running out in continuation of the Carmel ridge might easily be built of the limestone from the mountain, and there are still ruins of an ancient port near this headland. Not only is the harbour good, but the position of the place is most favourable as regards the remainder of the land. The broad plain of Esdraelon—the richest ground in Palestine—lies immediately inland and joins the plains, which stretch northwards from Carmel. The River Kishon runs down from Esdraelon to the sea, near Haifa, and along its course the roads to the interior rise with easy gradients. Haifa has, on the other side, easy access to the plains of Sharon. The great corn harvest of the Hauran is brought on camels by the Arabs, by the highway from Jordan to Acre, at the north end of the bay; the main roads to Damascus, to Beyrout, to Upper Galilee, and to Nâblus, all lead from Haifa.

It has lately been proposed to start the Euphrates Valley Railway from this port, and although the steep gradients in the Jordan Valley and the waterless deserts beyond may make this route impracticable, there can be no doubt that the railroad to Jerusalem should start here. The Jaffa-Jerusalem Railway would be a work of great engineering difficulty, because of the sudden slopes of the hills, which have a rise of 500 feet in less than half a mile. A railway to Nâblus from Haifa, and thence along the backbone of the country would be more easily constructed, and would form a more important line of communication leading to a better port. If the Jaffa line is ever made, it must follow the course of the Valley of Sorek, or it would never reach the watershed at all. It would be about 50 miles long, while the water-shed line through Palestine would not be more than 80, connecting Nâblus and Jerusalem with Haifa.

Appendix C.

Mrs. Chesney, the widow of the great pioneer, writes to me as follows:—

"So long ago as the year 1831, General (then Captain) Chesney had already appreciated the great importance to England of a line of communication with India through Mesopotamia. In his report to Sir Robert Gordon, from Bushire, after his first adventurous descent of the river Euphrates, on a raft and by native boat, he dwelt strongly on its advantages, both strategically and commercially. He saw its great value as a means of strengthening the Sultan's power in that country, and of bringing the Arabs under a settled form of government. He foresaw, even then, that this line 'might before long supersede the tedious route of the Cape'; and there can be no doubt that but for political jealousies, the anxiety of our Government to avoid all possible complications, especially with Russia, the Euphrates line of railway must have been constructed years ago.

"As years passed on, General Chesney only became more and more convinced of its incalculable importance to England, which was in no way lessened, in his estimation, by the opening of the Red Sea route. He saw in it the speediest and safest line of communication with our Indian possessions, as well as one of unspeakable strategical importance, both as an insurmountable barrier against and a firm support to Persia, while to our trade and commerce—suffering as it has been for many years—and now more than ever from non-reciprocity in free trade, he saw in the opening up of that most fertile of all the regions of the globe, a beneficial field of enterprise, such as no other country could offer.

"The Arabs are essentially a trading people, and keenly alive to their own interests. When General Chesney returned among them, both in 1857 and in 1863, they crowded round him with enthusiastic welcomes and eager inquiries why the promises and hopes raised by the Euphrates expedition has never been realised. With a glorious river, to be easily rendered navigable for the transport of heavy goods, with a country presenting scarcely any engineering difficulties for a line of rails, this glorious region has remained waste and neglected, and why? because of political jealousies and ambitious designs, which, in these days of international intercourse, should be thrown aside as narrow and unworthy of a great nation, with such a mission as that of England."

Appendix D.

The *Pall Mall Gazette* gives the following account of the last phase of the Kairoon concession:—

In the early part of 1876, a scheme for the regeneration of Persia was submitted by Dr. Tholozan, medical adviser to the Shah, and by an English commercial firm. The former advocated the introduction of capital into Persia, and the construction of public works. The first public work was to be the reconstruction of the dam at Ahwaz. At that time, although the concession was said to have been signed, nothing came of it. The intrigues decided Dr. Tholozan to abandon the affair. Now, however, the scheme has taken a more practicable shape. The Shah, when in Europe during the summer, broached the subject to some of his ministers; and four days ago a concession was signed by the Shah, giving to a French company virtually the right of property over a large part of the Arabistan province. It is stipulated that the company is to be a French one. It is to have the right to reconstruct the old dam at Ahwaz, over the Karoon river, and to construct any other dams thought necessary to irrigate the country lying southwards (for want of fixed boundaries the Persian Gulf has been made the limit in the south), colonise the country, open factories, have the sole right of navigating the Karoon, and remain in possession of the country under irrigation for a period of sixty-five years, commencing from 1881.

The promoter has one year, 1879, for making his

plans, which are then to be submitted to the Persian Government, and, in 1881, the works are to be commenced. The Persian Government is to have 25 per cent. of the net profits. Of all the schemes proposed to the Persian Government this is the most promising. As the river lies, on an average, twenty feet lower than the land, the country through which the Karoon runs is a desert.

The rainfall in Arabistan is not sufficient for agricultural purposes of any kind. On the banks of the river are a few small Arab villages and a few trees; inland there is no vegetation whatever. By the reconstruction of the Ahwaz dam, the district on both sides of the river will be irrigated, and an immense tract of desert made fit for agriculture. A few hundred years ago, there were immense sugar plantations at Ahwaz; with the failing of the dam they failed also. Cotton, indigo, wheat, barley, maize, rice grow well there, and a ready and easy export can be obtained, by means of the Karoon, into the Persian Gulf. The district has at present only a scanty population; but, if the intended change is carried out, the Arab tribes will come from all parts of the province and settle there.

It is fairly to be hoped that Ahwaz will, after a few years, become what it was a thousand years ago, when the town alone paid a yearly revenue of 3,600,000 dirhems to the Bagdad Caliph, and the province 50,000,000 dirhems—sums equivalent to about £430,000 and £6,000,000 at the present time.

The climate of Alwaz is said to be very unhealthy; a Persian historian goes as far as to say that the children are born with ague. Modern travellers, however, do not find the climate worse than that of Basrah and Muhamrah, two thriving, populous towns not far off. A plentiful water supply, with its consequent vegetation, will improve the climate. The navigation of the Karoon was years ago tried for by an English commercial firm. The English Government was asked for a subsidy of £4,000 per annum, and the Persian Government for permission to place steamers on the river; both demands were refused. Whether a French company or an English one have the right of navigating the river, the benefit to the Persian Government will be the same, but to the English merchants now trading in the Persian Gulf it can hardly be immaterial. I repeat that the scheme worked out by Dr. Tholozan is, without doubt, the best ever offered to Persia, and I should be very sorry to see it fail.

DISCUSSION.

The **Chairman**, in proposing a vote of thanks to Mr. Hyde Clarke, said he had always taken a deep interest in this subject, and had on various occasions visited some of the countries referred to, in order to form an opinion upon it. In 1866, he inspected the railways and ports of Italy, with a view to recommend some port by means of which our communication with India might be shortened, and on his report the Brindisi route was established. In that report, he felt bound to refer to the Euphrates Valley line, and concluded it thus:—"The question now to be solved is solely that of communication through Europe to the east of the Mediterranean. But, in saying so much concerning the postal routes to the East, I would ask your permission to touch also upon the still more important saving of time that may be obtained hereafter, by avoiding the passage of the Red Sea, when a railway shall be constructed from the coast of the Mediterranean, along the Euphrates Valley to the Persian Gulf. By this route, many hundred miles of distance, and many days of time, might be saved between London and Bombay, which will become within the next two years (when the railways to Madras and Calcutta are completed) the principal port of India. The navigation by the Persian Gulf to Bombay will be far preferable to that *viâ* Suez and the Red Sea to Bombay; and even that amount of navigation may ultimately be avoided, by the connection together of Bagdad and Bombay by railway. I have so strong a conviction of the important bearing that the construction of such a railway would have, commercially and strategically, upon the British Empire, that I could not but take this opportunity of recommending the subject to the serious consideration of her Majesty's Government." Mr. Hyde Clarke had also referred to the Committee of the House of Commons, which considered this subject, and he might read the concluding portion of its report, which was as follows:—"Speaking generally, your Committee are of opinion that the two routes, by the Red Sea and by the Persian Gulf, might be maintained and used simultaneously; that, at certain seasons and for certain purposes, the advantage would lie with the one, and at other seasons and for other purposes it would lie with the other; that it may fairly be expected that, in process of time, traffic enough for the support of both would develop itself, but that this result must not be expected too soon; that the political and commercial advantages of establishing a second route would at any time be considerable, and might, under possible circumstancies, be exceedingly great; and that it would be worth the while of the English Government to make an effort to secure them, considering the moderate pecuniary risk which they would incur. They believe that this may best be done by opening communications with the Government of Turkey in the sense indicated by the semi-official correspondence to which they have already drawn attention." There was thus high authority in favour of the railway through Turkey in Asia, and no one who considered the matter could doubt that it must be very desirable to complete the communication with India by railway. By the Suez Canal they had now the best sea route which could be found, and ultimately they must have railway communication by Vienna, Constantinople, and the head of the Persian Gulf to India. The old route round the Cape had been, first, superseded by the route *viâ* the Mediterranean; that again was accelerated by the Marseilles route; then again came the Brindisi route; and there were yet three further steps which would have to be taken, probably by degrees; first, that of the Euphrates Valley railway, from Skanderoon to the head of the Persian Gulf; second, a line from Constantinople to join that one; and lastly, through Persia to Beloochistan and India. Ultimately, this would have to be done, but it did not seem very easy at present. Mr. Hyde Clarke's proposals were very valuable, but the times were unpropitious, for all descriptions of securities had gone down; and it would be idle, he feared, to ask the British public to invest in any such line without a Government guarantee. He, therefore, saw no means of joining Great Britain and India by railway except by the co-operation of the British Government. It did not follow that the whole undertaking should fall on that Government, because others might contribute—the Indian, the Austrian, the Turkish, and perhaps one or two others. It would be very desirable that they should do so. He had sat at Constantinople at the Council table with Turkish Pashas, when in intimate communication with the Turkish Government, and he knew how vain it was to expect anything from them. The Canadian Government, having already two or three times as many miles of railway per head of population as we have in Great Britain, were undertaking, or had built, lines of great length, comprising 3,000 miles, for connecting poorer countries together. The Americans had constructed the Pacific line, and had contemplated two others. It was surely no great matter, comparatively, for Great Britain to compass—now that she had taken upon herself the protectorate of Asia Minor and Turkey in Asia—the construction and maintenance and security of 1,000 or 1,200 miles of railway, for the joint purpose of improving the countries in question, and of complet-

ing an all-rail communication between the 40,000,000 in the British Isles and the 200,000,000 in British India. Property, power, and influence, has its responsibilities as well as its rights. The one mode by which alone the former prosperity of these interesting regions can be in some measure restored to them is by railway construction, and facilities for free communication. If Russia were to make railways in this direction, it would not be with a view to our interests or commerce; but if the lines were undertaken under British auspices, they would form an international highway for the free intercourse of all nations.

Mr. Haddan, ex-chief engineer in the Ottoman service, said:—Every one discussing this grand subject seems to forget that, since the signing of the Anglo-Turkish Convention, the Euphrates Valley Railway question has completely changed. It is no longer a vital point to connect England or Europe, or even Constantinople, with India; but the question resolves itself into the establishment of a triangulateral, of which Cyprus is the base, and Bayazid, a town on the Russo-Turco-Perso frontier, and Grain, a port on the Persian Gulf, would form the two apexes. Any point south of the gulf of Iskenderun (the Syrian port for Cyprus) is shut out of this combination owing to the impracticability of the Amanus Range Spurs; so the question of the port becomes confined to Ayas. The real alternative value of the Euphrates Valley Railway in the event of the Canal being blocked, is to be measured by the additional distance it moves the final point of transhipment nearer to India; since from Grain to Kurachee the few ships available on the Indian side can, by repeated short journeys, do as much duty as the many and larger supply in the Mediterranean, and thus assure that evenness of supply which constitutes the first requirement of any transport service, military or civil. Speed is not important in a military sense, as it only anticipates the first delivery. This is one of the most solid arguments which can be used in favour of an overland line to India, though I have never heard it advanced by its promoters. Mr. Hyde Clarke has referred to the Pioneer system, which purports, for the same outlay as he contemplates and in far less time, to cover the country with a network of steam caravans in lieu of one trunk line. In design, the Pioneer is in form and attributes a kind of cross between a railway proper and the telegraph; and being portable, it does not hamper the future with a makeshift but ineligible guage; a fatal mistake Mr. Hyde Clarke, I am glad to see, has foreseen. My system requires no local labour for its construction, the whole being producible, and to any extent, in the iron foundries of the world; whereas the far greater portion of the Grand Trunk Railway in question must of course be performed locally, a work which would require no less than 50,000,000 days' labour to execute, under the most unfavourable conditions; labour far better employed in tilling the land and creating produce for the iron Pioneer horse to carry to the Europeau market, to pay the bondholder with.* In addition, no continental trunk line ever yet paid without branches. Consul Skene gives his opinion that the construction of such a work would practically ruin the country by attraction of labour; the rural population being only about seven able-bodied men per square mile. Besides, where is the money to come from? Mr. Hyde Clarke himself acknowledges that the long innings of the railway financier are over, as is also the vague notion that much local good is done by the mere speuding of money in a foreign country. The money must be earned!—the starting capital being iron, in our control, and not gold, in theirs. What the Pioneer offers is an immediate 5 per cent. dividend. And, in addition facilities of deferred payment, since the railway is available as security, the whole structure being of intrinsic value. The system, moreover, can be introduced to any desired extent, without interference with the agricultural labour market. India has given us ample warning of the evil attending the stereotyping of English railways all over the world, in defiance of the well-known proverb to cut the coat according to the cloth. Its Government refuses to guarantee any further lines even within its own limits; and with reason. The South Indian Railway, by no means a second-rate undertaking, for it is 600 miles in length, and cost £6,500 a mile, carried last year (the famine year) only 162 tons of freight daily, or about one-tenth its full capacity. All chance of a dividend with such a limited traffic was impossible. Why, each ton carried one mile had to satisfy a capital equal to £40; £13 being the amount of capital which one ton can earn a dividend of 5 per cent. upon. The South Indian, therefore, if it had been dependent upon goods alone, would have earned no dividend, but the number of passengers was so great as to produce a dividend of $4\frac{1}{4}$ per cent. India has, however, a population of 210 to the square mile, and Turkey in Asia only 23; aud therefore we cannot hope to count upon passengers for a dividend. From statistics taken upon the most frequented route in Syria—viz., from Aleppo to Alexandretta—the existing traffic does not average 100 tons daily.* Whereas, to pay 5 per cent. on a capital of £13,000 a mile, which is far below the mark, a daily traffic of 1,000 tons is required. Of course better figures may be produced by calculating on a higher tariff than the Indian; but a high tariff is indefensible, for it contracts the area of country available for export, while imports are handicapped thereby. A low transport tariff, by promoting trade, raises very rapidly the local value of money, and enables larger import purchases to be made. A high tariff simply kills the goose which lays the golden eggs. The local obstacles to ordinary railway enterprise in such countries are so serious, that no one intimate with its details would ever dare hope to see the work promptly carried out on the ordinary type, even with unlimited credit to support it. Turkey wants a trade revolution to give it life—a rapid and striking one! Driblets of 30 miles of road a year will neither satisfy their political position nor their creditors. Its communications must progress by thousands of miles annually, and be constructed entirely by extraneous effort; for all its men, muscle, and energy are wanted to remove the effects of the war, and to cultivate the soil. Agriculture affords the most rapid known means of producing wealth with limited means, if it has a market. It has the merit, moreover, of not being in any way a novelty or a reform. The further introduction of railways of any sort in Asia Minor or Syria, is, however, premature, until proper means have been taken to organise and make the most of the existing animal transport, since the Turkish lines already open have attracted an undue portion of the carrying-power of the Empire, to the detriment and ruin of some of the remote districts. Mr. Austin, M.I.C.E., has published a work on Turkish railways, which every bondholder should treat as his own text-book. A semi-official company might with great advantage, both to the bondholders and the State, take over on requisition (not purchase) the whole of the animal transport. It would merely undertake as an intermediary the equilibrium of the supply and demand, but in an intelligent instead of hap-hazard style, and act as it were as transit-brokers, or like the "Mukadums" of India, who do the head work for their clans of porters, mule and camel drivers, &c. The company would possess, however, the monopoly, so that no one but themselves could fetch or carry on the highways.† They would

* Mr. MacCoan, in the December number of "Fraser," has illustrated the difficulty of finding abour, Turkey having only constructed 600 miles of so-called roads in 30 years—J. L. H.

* Mr. McCoan's figures give 50 tons, at £6 per ton.—J. L. H.

† Already given to the Damascus Company on the road they constructed between Beyrout and that city, which, opened 16 years ago, has never paid a dividend.—J. L. H.

introduce a fixed tariff from place to place, not necessarily established on mileage considerations alone, and thus give merchants the means of going largely into export operations, an impossibility now, since transport rates fluctuate 100 per cent. during a season. Their staff would be also available for improving means of communication generally, or establishing police control, or even for levying taxes in the form of transit-dues in lieu of *in situ;* the system* also would be available for our Government for supervising the internal enconomy of the country, since the organisation in question exerts its influence to the uttermost corners of the empire. They might freely do so in this sort of fashion, so well suited to the Turkish official mind, who will certainly resent and render abortive all open attempt at reform, or any direct interference on our part. All our efforts are unfortunately looked upon by nearly all classes as the first attempts at foreclosure on the part of the sordid usurer, the English giaour; which unenviable character is all we have gained by lending, I might say giving, the Turks a few hundred millions or so. The grinding down of the peasantry by the Pachas, for their own purposes, was all along sedulously imputed by them to the avarice of the European money-lender, whose Armenian prototype hardly a peasant has not a lamentable experience of, and whom they, naturally enough, class with us—as fellow-Christians. Any innovations coming from us will be reeeived with suspicion, if nothing worse, consequently a brilliant policy cannot be followed; but if the game is worth the candle, we must do the work in a semi-Turkish fashion. Leave the Padishah the honour and glory, but secure the solid advantages as a means of paying our bond-holders by self-conducted trade, and not by financial hocus-pocus, or loans entrusted to others to spend. We should also have the merit of introducing order at the same time, Any organisation possessing the monopoly of transport, in an Empire like Turkey, is more than, financially speaking, master of the situation.

Mr. Lee Thomas did not agree with the last speaker that no trunk lines ever paid. The Pacific Railway answered very well, and he believed the Euphrates Valley would also, and he thought the argument he had adduced that the amount of traffic which would exist between Alexandretta and Aleppo had no bearing on the case. It must be borne in mind that if the railway were made, Russia would still have quicker communication with that part of India now occupying so much attention with ourselves, by way of Tiflis, and the length of railway they would have to make would be comparatively short.

Mr. Hepworth Dixon said his special interest in this portion of the world lay chiefly in Syria. As one of the founders of the Palestine Exploration Fund, and as chairman of the committee, he felt a great interest in that portion of the route. They had recently finished a great survey of that portion of Syria, and of the Turkish Empire, which would, in due time, be published, and he thought that, whatever course the railway might take, it should be so arranged that Jerusalem, Damascus, Nazareth, and Hebron, should have some points of contact with it, so as to bring such sacred countries into more direct relation with the rest of the Christian world. With regard to Cyprus, having only left it twelve or thirteen days ago, he could assure his friend, Mr. Hyde Clarke, that the doubt whether we should be able to stay there or not was entirely superfluous. We had taken Cyprus, as we had many parts of the world which suited us, for certain purposes, and we had never beeu driven away by reports that some one had taken a little fever, or something of that kind. He had beeu in Cyprus in the very hottest time, and never felt the smallest disposition to feverishness or illness of any kind, except a purely mechanical accident, and he believed even his rapid recovery from that was due to the magnificence of the climate. He stated that with full knowledge of every camp in the island. The death-rate and sick list in Italy, France, and Malta, had been, during the whole of the summer, much higher than in Cyprus. That Cyprus gave a base for commencing the railway from the opposite coast of Syria to any portion of the Persian Gulf they liked was an absolute certainty. In the island there existed, built up by nature for us, and requiring very little for its completion, one of the finest harbours in the world, Naghoussah, called by the Genoese colliers Famagosta. In the harbour there was a space of deep water sufficient to let the British fleet ride safely, and he had himself heard the Admiral of the Channel squadron say that, if it was desired, he would take in three of the largest vessels in the fleet, and put them inside the reef without the smallest hesitation. He had himself visited the natural harbour twice by sea, and from the moment you got within the reef you could not help feeling that for $2\frac{1}{2}$ miles along the shore line, from what was formerly Salamaz to the inner harbour and Naghoussah, there was a perfectly protected natural harbour, which, at a very slight expense, put by the engineer at £14,000, could be made a perfectly safe naval station and arsenal for all the Imperial purposes of England. At such a harbour from one side, close to the Syrian coast, you had a point *d'appui* for any enterprise of this kind. Shortening of distance meant a saving of time, and the slightest glance at the map would show how much could be done in this way by the construction of this railway, forming a direct line from London to Constantinople, and on to Bombay. However much it might be delayed by temporary circumstances, it must ultimately be carried out. The right way would be, not to make temporary lines, which would have to be undone, but to make a good line, and follow it up as fast as possible.

Mr. Juland Danvers said it was impossible in these days for any civilised nation to be stagnant on the question of communication, and we had fair ground to expect that as much would be done in the future as had been done in the past. Many present would recollect the time when the overland route was considered a magnificent thing, and the revival at present of the question of overland communication through Asia Minor showed that the spirit of this country was still alive to the necessity of improving our communications with India. Although he did not profess to be anything like a prophet, he could not help foreseeing that the time was approaching when the necessary consideration would be given to this matter, and the means be taken to carry it out. The portion of the paper with regard to the financial part of the question deserved consideration, but he could not hope for much success at the present moment. At the same time, we might hope that times would improve, and that capitalists would be more ready than at present to embark in such an international enterprise. He trusted that Mr. Hyde Clarke and others would continue their exertions, and at length reap the success they deserved.

Colonel C. E. Gordon, R.E., said he had not had the advantage of hearing the whole of the paper, but the line which seemed to him had the most chauce, however small that might be, of receiving good support, was the one starting from the Mediterranean, either from Silusia or Alexaudretta, passing by Aleppo, from thence taking the shortest route down the Euphrates, following the right bank to the northern end of the Persian Gulf. His reason for taking that line in preference to any other was chiefly on military grounds. They all knew the advantage of having two strings to your bow, but, at the present moment, the only real string of any advantage, in case of warlike emergency, was the Suez Canal, and that might be rendered

* Thus getting rid of the tax-collecting curse and also its expense.—J. L. H.

perfectly useless in a quarter of an hour, either by sinking one or two ships, or blasting the walls of the canal. Then we were driven to the old route round the Cape, except that there were the railways through Egypt, but the same cause which would interfere with the canal would probably render them useless. But in the present day, when decisions had to be rapidly come to, and quickly followed up, the Cape route was almost valueless. They were, therefore, driven to look for another route, which must, at the same time, be as short as possible, and that was one through the Euphrates Valley. When he was living in Turkey in connection with the Public Works Department, there was a line proposed starting from Alexandretta, and after passing Aleppo, going further north, and then coming down the Tigris to Baghdad and Bassorah. That route would, very likely, be more advantageous as regards immediate results, but, from a military point of view, it had the disadvantage of placing us at the north, the side from which we should be most exposed to attack, with two rivers in our rear, whereas if you followed the right bank you had these two rivers in front. A previous speaker, in estimating the cost of railways and the necessary amount of traffic to produce a satisfactory return, mentioned a cost of £13,000 a mile, but he should regard that as excessive. He should construct the lightest possible line, begin at the earliest possible moment, and get returns. He had not the slightest doubt that the very existence of the line would soon produce traffic.

Mr. Hale had no doubt that, if railways were made, they would open such an amount of trade as to make them pay their way; but he deprecated a Government guarantee.

Mr. MacCoan said he had resided some time in Turkey, and had some acquaintance with the Asiatic part of the route contemplated, and also with the route from Scutari down to the Persian Gulf. His personal impression as to the relative merits of the two schemes, was this:—He was more or less familiar with Mr. Andrew's projected route by the Euphrates Valley proper, and had also a clear recollection of the line proposed to be traversed by the other route now proposed by two great authorities, Sir Macdonald Stephenson and the Stafford-house Committee, and he must say, with deference to Colonel Gordon, that he thought he was under some misapprehension as to which bank of the Tigris was proposed to be followed; for as he understood it, there would be only one river in the rear. That route had the advantage of keeping in Mesopotamia proper, passing through a cultivated country, and by a route which for thousands of years had been the line of traffic. Mr. Andrew's line, on the other hand, passed for a great part of the way through a desert. There was not a place on the line worth calling a town, or hardly a village. The other ran right through the centre of Asia Minor, joining the present short line to and there again it would run through a nearly continuously populous country. Mr. Haddan was an authority on these subjects, but he did not at all share his opinion as to the cost of these lines.

Mr. Haddan said his estimate was Sir John McNeill's.

Mr. MacCoan thought about £11,000 was considered by high authorities to be sufficient for the ordinary English gauge. The most encouraging line would require an immense amount of money, and that was the difficulty. Sir Macdonald Stephenson proposed to meet that by a contribution of labour. Mr. Haddan seemed to think that was a cardinal objection to any scheme, but he did not at all agree. It was an established practice throughout the East, and did not create any grievance in its operation. It was quite common to give *corvee* labour for public works for six or eight days in a year, and that was given, on the whole, willingly for any local work. Both the Aidin and Cassaba railways were very popular, and he had little doubt that a moderate contribution of labour would be given without much grumbling.

Mr. C. E. Austin, said they found no difficulty in getting labour to make the railway from Smyrna to Cassaba. With one gang of 500 men in Persia, another similar gang in India, and another in Turkey in Asia, the whole line from Constantinople to India might be made in five years; so that, after all, the work in that respect was not difficult. The financial part of the question caused the difficulty. As to passing through these savage countries, as soon as a railway was commenced the people became almost civilised. All the policemen on the Smyrna and Cassaba line were the mountain robbers of whom they heard so much during the war in Turkey, and they found no race of men who made better policemen; they had moderate wages, regularly paid, and became contented and honest. Turks, Greeks, Montegrins, and Koords, all came willingly to work, and by setting one race to emulate another they were able to get much more work out of them. There were very few engineering difficulties in Asia Minor, or in Persia, and what there were could no doubt be easily overcome.

Mr. Ward thought the commercial side of the question should be considered as well as the military, and he must say he felt disappointed that he should have to leave the room without a clearer knowledge of when it would be likely that the line would be opened. He had been connected with India for many years, and wanted to go there himself, but could not spare the time. If this communication were made to Calcutta, many like himself who were now deprived of the privilege of running over and taking a view on the spot would be able to do so.

Mr. J. Laffan Hanly, having lived many years in Turkey, thoroughly agreed with Mr. Hyde Clarke that the line would be an immense advantage, but in his opinion the benefit would be principally to the British people and Government, and it must be through the initiation of the latter that it would be carried out. Neither the Turkish Government nor people could do anything.

Mr. Hyde Clarke, in reply, having thanked those who had taken part in the discussion, said those who had not hitherto taken an interest in this subject would see that there were many, at all events, who did so. He had been entrusted with a copy of a railway map made in Turkey, showing that, even under present depressed circumstances, this important subject had the attention of Government, and he had intended to bring it, but, by mistake, he had brought a map of Cyprus instead, and probably that had inspired Mr. Hepworth Dixon. The labour difficulty had been practically met by Mr. Austin. The railways were carried out, and some of them very well, so far as labour—so far as actual work was concerned. A great mistake was often made about the facilities afforded to such works by the fact of there being plenty of labour at 6d. or 1s. a day. The moment you began the works you raised the price of labour against yourself; nearly all railways were practically made by special labour, and the fact that there was or was not a large population in the district made really very little difference. Mr. MacCoan has raised an important point with regard to contributions of labour, and he should have liked Colonel Gordon to have answered it, as he had been president of the Council of Public Works at Constantinople, which formed a very well devised plan for making roads in Turkey. Unfortunately, the people did not care about roads, and he had great trouble with it, but the system was a very good one. The contribution of so many days' work by each man in his own district, was the same system as formerly existed in England under the name of the labour rate, and was still continued in some

parishes for highway purposes. Now people in Turkey generally preferred to pay in money. Iu a fairly peopled district, the value of the contribution was about £1,200 a mile; but that would not apply throughout the line. At all events, it was a practical proposition to get a contribution from the localities, though, perhaps, not at present, as the country was in such a state of depression; but if a little time were allowed for recovery, it would be always found that any city would be willing to contribute men or money for a public work of this kind. The case, therefore, was not so helpless as it appeared to some. He was sorry to say the Chairman had, to some extent, misunderstood his financial proposition, but that was the difficulty in which he placed himself by uot sufficiently developing his ideas. He quite acknowledged that this was a time of great crisis, and that a Turkish guaranteed loan could uot be put on the market at all. What he proposed was, that limited sums should be temporarily advanced from time to time for the purpose of making the works, which could be mortgaged, and the mortgage bonds of those sections, as they became productive, might be put ou the market as a five per cent. security. Thus the Government advauces would be realised, and they could go on making fresh portions of line. He believed the cheapest mode of raising the money was by a guarantee from the English Government. If the line were uuder the inspection of Government, they might fairly assume that the bonds for the cost of it could be placed on the market. But as the Government was, unfortunately, not disposed to give a direct guarantee, he proposed this plan as an expedient, that it should make advances in the nature of the advances by the Public Works Commissioners here, so as to create portions of the line, which, with the adjacent revenue of the country, would constitute an income on which bouds could be issued to repay that which had been advauced. One reason why he put forward this view was, that if it were pressed on the Government by influential parties, most likely the Government would be forced to say—we had better give our own guarantee; if we are to do it, let us go right through.

A vote of thanks to Mr. Hyde Clarke was passed unanimously, and the meeting adjourned.

The paper was illustrated by a large diagram map of the country referred to, which was lent for the occasion by the Royal United Service Institution.

MISCELLANEOUS.

MACHINES FOR THE ELECTRIC LIGHT.

In the *Journal* of the 22ud November, an attempt was made to give a popular explanation of the different varieties of lamps or regulators used for electric lighting. Some readers of that article have suggested that a similar sketch of the machines used might be useful, and so it is now proposed to offer to those who have recently taken au interest iu the subject a short description of the generators or machines most extensively used to produce electricity. In doing so, the object will be to avoid technicalities as far as possible, and no attempt will be made to give more than an outline of the leading principles. The subject is by uo means an easy one, and to understand it properly a practical knowledge of electrical science is required. As with the article of which the present one is a continuation, it is requested that electricians will kindly pass over the next few columns of the *Journal*, for they are intended solely for those who require a little simple information on a subject now attracting a great deal of popular attention.

As nearly all telegraphic apparatus acts by the power possessed by an electric current of converting into a magnet a bar of iron around which it flows, so all the apparatus employed for the mechanical production of electricity depends on the power possessed by a magnet of inducing, in a coil of wire surrounding it, or in close proximity to it, a current of electricity. In the latter case the current is only momentary. It is produced at the instant of placing the magnet near to or within the coil, and again at the instant of removing it. It is produced also when any chauge occurs in the condition of the magnet. These momentary currents are too fugitive to be employed —separately—for practical purposes, but it is easy to conceive that if they can be caused to succeed one another with sufficient rapidity, a current might be obtained which, for all practical purposes, would be as effective as a continuous current. Such is actually the case, and magneto-electric machines, as they are called, are simply devices for causing rapid alterations in the relative positions of the magnet and the coil, and a cousequent rapid succession of momentary currents. The machines employed to produce this effect vary greatly in their arrangements, and it is hardly necessary to say that the simple principle stated above is worked out and extended until the result is a complicated and elaborate apparatus, whose action it is difficult even to follow without having a very considerable knowledge of electrical science. The non-scientific reader can, perhaps, hardly expect to gain a thoroughly clear idea of the action of these wonderful machines, but perhaps it may be possible to convey to him a general notion of the way in which they work, and this is the final aim and object of the present article.

Among those whose names should be recorded as having constructed practicable machines, or having by their researches aided the development of the principle, ought to be mentioned, after Faraday, the great discoverer of the principle, Pixii, Saxton, Clarke, Niaudet, Henley, Wheatstone, Ladd, Gramme, Siemens, Wilde, Nollet (the inventor of the "Alliance" machine), Holmes, Lontin, Wallace and Farmer, De Meritens, and Brush.

The simplest form of magneto-electric apparatus is seen in the small machines used for medical purposes. In these an electro-magnet is mounted so as to revolve close to the pole of a permanent magnet. The electro-magnet of course consists of a pair of wire bobbins, each surrounding an iron core, which is secured to au iron piece at the back. The iron cores and the connecting iron back form a shape corresponding to the usual horse-shoe. The electro-magnet is fixed on a spindle, to which rapid rotation is given by suitable means. Of itself, the electro-magnet possesses uo magnetism, but as its poles rapidly pass before the poles of the permauent magnet they are magnetised, each with au opposite polarity to that of the pole of the permanent magnet. As each pole of the electro-magnet passes before each pole of the permanent magnet once in each whole revolution, it is evident that it is magnetised twice, and becomes once a north pole and once a south pole. These rapid changes in the magnetic condition of the iron cores, produce corresponding electrical currents in the coils of wire surrounding those cores, and there are produced in each bobbin, during one revolution, two short currents in opposite directions. The two bobbins are wound in such a manner that the current in both is always in the same direction, so that, as it changes direction in the one, it also changes direction in the other. In order to pick up these instantaneous currents and convert them into a steady, continuous current, a "commutator" is required; and it is evident that, even apart from the need for "reversing" the current, some device must be employed for carrying off the electricity which will not interfere with the free movement of the bobbins. The

"commutator" is formed of two metallic pieces secured on the revolving spindle, one in connexion with each end of the wires on the bobbins. These, of course, turn exactly as the spindle does, and, consequently, as the bobbins do. As they turn, they come alternately in contact with a pair of fixed springs. The effect of this arrangement may be said to be that, as the current is reversed, so the delivery to the sprugs is reversed, and each spring receives only the current which flows in one direction. Wires connected to tho springs take up this current, and convey it to the point where it is required. Such may be considered the typical form of the electro-magnetic machine. A fixed magnet has an electro-magnet mounted so as to revolve close in front of it, or, in some early forms of the machines the permanent magnet revolves, and the electro-magnet is fixed. The changes in the magnetic condition of the electro-magnet produced electric currents in the wire surrounding it, and by means of a commutator, the currents are, as it were, sorted out, currents of the same direction being seut off into one wire, while the opposite currents are sent off into the other wire. Hence we get a continuous current of electricity, similar to the current from a voltaic battery, and capable of producing similar effects. Currents from magneto-electric machines can be, and are used for telegraphy, electro-plating, and electric lighting, as well as for experimental and scientific purposes.

For the first of these purposes (telegraphy), the machines used are practically very much of the character of the simple apparatus above described (of course so far only as relates to the generation of electricity), except that no device is used to produce a continuous current, the alternate currents being equally efficient for telegraphic purposes. For electro-plating, and for electric lighting, large and powerful machines are required, capable of producing "torrents of electricity," and driven by powerful steam-engines instead of by the hand of the operator. The first machine of this character was that made by M. Nollet, of Brussels, and has been since improved by M. J. Van Malderen and others into the Alliance machine. In this several rings of bobbins are mounted on a horizontal axis, to which motion is given from a steam-engine. Outside these bobbins are corresponding circles of permanent magnets on a frame surrounding the rotating axis. The poles of these magnets all point inwards, and the bobbins as they rotate are carried rapidly past them. A current is thus set up in the wires of the bobbins in the same way as, but naturally of very far stronger character than, in the small machine with only a pair of bobbins. The number of rings of bobbins varies in different machines. In one example of this type of machines there were five circles of horse-shoe magnets, each containing eight magnets and four rings of bobbins, with sixteen bobbins in each ring. In another, constructed for light-house purposes by Mr. Holmes, there are two rings of bobbins, forty-four in each ring, and three series of magnets. It will be observed that there is one more set of magnets than there is of bobbins, the object of this being to allow each ring of bobbins to pass between two sets of magnets and thus be acted upon more powerfully. A special feature in this machine is that it has no commutator, and, therefore, the currents from it are alternately of opposite directions. As regards electric lighting this is maintained to be of little consequence. Indeed, for some purposes, it is considered an actual advantage, as it ensures an equal consumption of both carbons in the lamp. Inasmuch, however, as the rapid alternation of current involves loss, there are counterbalancing advantages and disadvantages, and it is yet a disputed point on which side the gain lies. The current traverses all the bobbins of the machine in succession, the wire from the first bobbin of the first ring being attached to the wire of the second bobbin on that ring, and so on through all the bobbins on that ring. From the last of them it goes to the first bobbin on the second ring, and in a similar way it traverses all the bobbins of the second ring, and so through the whole machine. It will be understood that the alternating currents succeed one another with immense rapidity—some 60 to 80 times in a second. In later machines made by Mr. Holmes on this type, there were various improvements, and the principle, shortly to be described, of substituting electro-magnets for permanent magnets, has been employed by him in his most recent machines. It was one of the first of the Holmes' machines which called forth the remark from Faraday, on the machine being shown to him, "You have made my baby into a man."

The power of such a machine as the "Alliance" is of necessity limited by the power of its permanent magnets. A great step in advance was made when for the permanent magnets electro-magnets were substituted. Mr. Wilde is believed to have been the first to conceivo this idea. He employed the current from a small machine with permanent magnets to magnetise electro-magnets, which in a large machine supplied the place of the permanent magnets previously employed. Their action was in every respect equivalent to that of permanent magnets, but they were far more powerful. Even this plan, however, was soon surpassed by the remarkable discovery made simultaneously by Siemens, Wheatstone, and Varley, that a very feeble magnet might be made to magnetise itself, the curreut induced by it being led round itself, and that any iron once magnetised retained sufficient magnetism to start this cumulative action. The electric current, and the magnetism produced thereby, act and re-act upon each other until the full power of the machine is reached. The machines made on this principle are known as "dynamo-electric" machines, while those with permanent magnets are called "magneto-electric." The term "electro-magnetic" again is reserved for those machines in which electricity is the driving power; machines, that is, in which motion is produced by an electrical current.

Another important improvement, earlier in date than the last named, was the bobbin or "armature" of Siemens and Halske. In this the insulated wire is wound longitudinally on a bar, the section of which is ⊢⊣ shaped, there being on each side of the bar a groove, running from end to end. The wire, when wound on, fills up these grooves, so that the shape of the complete armature is cylindrical. The armature revolves round its longer axis, and between the poles of a magnet or electro-magnet (according to the class of machine used), as close to them as possible. The current generated therein is brought to insulated pieces on the axis, and is collected therefrom by metallic springs resting against them. This form of armature is employed in the earlier forms of Siemens' magneto-electric machine for telegraph purposes, also in Wilde's machine, and in the machine of Ladd, which it is believed was the first dynamo-electric machine used for the production of light. The present form of Siemens' machine has an armature of a differeut character, as we shall see further on.

Iu the Wilde machine a large Siemens armature rotates betweeu the poles of au electro-magnet, formed of two massive iron slabs, round each of which is coiled insulated wire. These iron slabs form the sides of the machine, and are united by an iron plate above, which forms the top. This, in effect, produces a horse-shoe magnet, and some similar arrangement is employed in many machines, the solid masses of iron which constitute the fixed magnets being frequently utilised to form part of the frame. Upon this top plate is mounted a similar smaller machine, but with permanent magnets. The current from the small machine is used to magnetise the electro-magnets of the large machines, and the current from the large machines is led off by wires to the point where it is to be used. The armatures of both machines are driven by pulleys upon them, round which pass belts from a steam engine.

In the present form of the Siemens machine, two broad horse-shoe electro-magnets are mounted, side by side, on a base-plate, with their poles opposite each other. Between these poles is the armature, which is of a length just equal to the breadth of the plates forming the electro-magnets. The armature in construction apparently resembles the original Siemens armature above described, but its action is quite different. Instead of an iron centre with two opposite grooves, the centre piece of soft iron is cylindrical, and on this the wire is wound lengthwise in a number of distinct coils or sections, instead of all the wire being wound in a single continuous coil. The wires now entirely cover the cylinder, instead of, as in the original armature, leaving about half the surface of the core uncovered. The wires of the several sections are brought down to insulated pieces on the spindle of the armature, and metallic pieces, or "brushes" resting against these, receive and transmit the current. The way in which these wires are "coupled up" is such that a continuous current flows into the brushes and from them along the line. Curved iron bars, which are prolongations of the cores of the electro-magnets, fit closely round the armature. The current is led from the armature round the electro-magnets, and magnetises them on its way to the lamp or other apparatus, where the current is to be utilised.

The Gramme machine, the next we come to in our hasty survey, involves a still further set of considerations, and is, perhaps, still more difficult to explain readily than any of the preceding. Consider an iron ring lying flat between the poles of a horse-shoe magnet and in the same plane. The poles of the magnet will produce poles at the two points of the ring nearest to the magnet. If the ring be moved round, the poles will shift their position in the ring, but will keep the same position as regards the magnet. However fast the ring may revolve, its magnetic poles will always hold the same position in space. Now let the ring be covered with insulated wire, wound round it so as to form a continuous unbroken helix about the ring at every part. This helix will be the seat of a current caused by the constant alterations in the magnetic condition of the different parts of the ring. To obtain this current and carry it off, it is only necessary to remove the coating from the outside of the insulated helix, so that springs pressing against it, one at either side, at points intermediate between the poles, may come into metallic connexion with the wire. In practice, the same effect is produced by joining the wire at short intervals to strips of metal on the axis of the ring, and fitting "brushes" to bear against these strips. In small machines for laboratory use a permanent magnet is employed, but in all machines intended for industrial purposes the magnet used is an electro-magnet, magnetised by the current from the machine itself. It will be observed that the current from the Gramme machine, like that from the Siemens machine just described, is continuous, and in one direction, so that no device is required to reverse it, as in machines with alternating currents. In the present construction of the Gramme machine, the circular armature rotates on a horizontal spindle between the opposite poles of two electro-magnets mounted vertically, and in the same plane as the spindle. These electro-magnets are so arranged that they compose the whole frame-work of the machine. As in the Siemens machine, soft iron pole-pieces are mounted on the electro-magnets, and closely embrace the armature.

The above brief descriptions may perhaps suffice to illustrate the main principles on which dynamo-electric and magneto-electric machines are constructed. In the different machines now used, or proposed for use, these main principles are employed in various ways and with modifications of greater or less importance. The value of these various modifications it must be left for experts to decide, with the simple remark that changes of apparently an insignificant character may really have the greatest effect on the practical working of a machine. The only intention of the present writer is to describe the salient features of each machine, not to attempt to discuss the more abstruse questions which arise in the working of all of them, or to institute any comparison whatever amongst them. Without, therefore, offering any opinion as to the value of the many different systems, it may be sufficient for our present purpose to notice some of the machines now before the public, and the principal differences in their general arrangement.

In the Lontin generator a number of bobbins are mounted radially on a central revolving spindle between the arms of a massive electro-magnet. These arms are vertical, and rise from the base plate. The bobbins are mounted on their spindle so as to form a series of circles thereon, and the connexions are so made that the current from each circle of bobbins may be obtained separately. Thus as many distinct electrical currents may be obtained as there are circles of bobbins. This is a most important point in the matter of electric lighting. But besides thus producing several currents from one machine, M. Lontin has made an apparatus for the special purpose of dividing an electric current. In this the current from the generator is caused to magnetise a number of electro-magnets mounted radially on the circumference of a rotating disc. Surrounding this disc, and concentric with it, is a second stationary circle of electro-magnets, with their poles facing the poles of those on the disc. As the disc is put into rapid rotation, currents are induced in the stationary magnets, and these are so "coupled up" as to give currents of the required force and number. This dividing apparatus, it should be noted, is, in fact, also a generator. In principle, it is indeed a recurrence to the system of Wilde, in which a small machine is employed to excite the magnets of a larger one. The current in the first Lontin machine might be insufficient for a single light, though the currents in the larger machine might each be sufficient to supply one or more lights. A machine, having a similar effect, has also been made by M. Gramme. In this also a number of electro-magnets are set, on a central rotating axis, and this is surrounded by a fixed ring, on which insulated wire is wound in a series of sections. The different sections are coupled up as required, to give the number of currents necessary, an arrangement which is much facilitated in this, as in the Lontin machine, by the fact that the series of induced magnets which form the ring are all fixed.

In the Wallace-Farmer (American) machine, two circles of bobbins are mounted about the centre of a horizontal spindle. Each ring of bobbins faces the ends of a large electro-magnet, one arm of which is at the top of the frame and the other at the bottom. There are, therefore, two such electro-magnets, one at each end of the frame. The machine being thus double, either half may be used to produce a current, or, as is more generally the case, both halves may be used together for the production of a single current. The inventor prefers to drive by means of two pulleys, one at each end of the rotating axis, as by this means he considers he gets more uniform motion.

Another American machine is the Brush machine. In this, two large electro-magnets are set, with their poles facing each other, and between them is a revolving ring, resembling the Gramme ring, except that the wire is not entirely covered with the coils of wire. There are a number of uncovered spaces, which are filled by extensions of the ring, so that the complete ring presents a series of short coils alternating with short surfaces of iron.

The De Meritens machine, a modification of the Alliance, is one of the most recent forms produced. In this an armature resembling the Gramme ring, but divided into several segments, magnetically insulated one from another, rotates in front of a series of permanent magnets, arranged round the axis on which

the armature rotates, and parallel thereto, instead of being set radially, as in the Alliance machine.

Such, in brief outline, are some of the best known machines at present in use. It may be interesting to mention some of their actual applications in this country for purposes of electric lighting. The Siemens and Holmes are both used for lighthouse illumination. The Siemens is also used in numerous factories, and in some of the few London shops which have recently exhibited an electric light. The Royal Institution now possesses a Siemens machine, with an engine, &c., by which it is intended to light the lecture theatre. The Albert-hall, also, it is believed, is to be lighted by two of these machines. A number of Siemens' machines have been purchased by the Government for military and naval purposes. Gramme machines are used at the *Times* office to work the Rapieff lights now shown there, at Billingsgate with Jablochkoff candles, and in some other shops in London. They are also to be used for the experimental lighting of the Thames Embankment. The chief use of the Gramme, however, has, up to the present, been on the Continent, where it is very largely employed. The magnificent illumination of the Avenue and Place de l'Opera, in Paris, was all carried on by Gramme machines. The Lontin system is at work at the Gaiety Theatre, in the Strand. It has been for some time at work in Paris, at the St. Lazare and Lyons Railway Stations. Several Wallace-Farmer machines have been brought over to this country, and are being shown by Mr. Ladd, but the writer is not aware that they have been put to much work, as yet, in England. Also he is not aware that any Brush machines have, up to the present date, made their appearance here. In America the Brush machine was the one selected by the committee of the Franklin Institute after trial with a Gramme and a Wallace-Farmer. No De Meritens machine either seems yet to have crossed the Channel. There are, doubtless, other instances of the public use of the machines in England, but the above are, at all events, some of the principal.

PRODUCTIONS OF CORSICA.

Consul Shortt, in his report upon the trade of Corsica for the year 1877, gives an account of some of what may be called the "specialities" of the country. In tho first rank comes the olive oil: the greatest quantity is produced in the north-west part of the island, and this is quoted at the highest price of all imported oils in the Nice market. A considerable quantity is also bought for the Italian market, when it is re-sold as the best Lucca oil.

The lagoon of Biguglia, near Bastia, is the feeding and breeding place of immense shoals of grey mullet, *muges* (a sort of mullet), loups, and eels. The fish are sent to Leghorn, Nice, and Marseilles; the eels are sent to Naples only, where they are considered a delicacy. The roe of the mullet is dried and fetches a good price —"bontarga" is what it is called, and a sandwich made with grated "bontarga" is said not to be despised. This lagoon, during winter, is the resort of great numbers of wild fowl, especially coots; from time to time *battues* are organised, and quantities are shot. A number of boats form line, and drive the birds towards the shore; when near, they rise, pass over the boats, and are shot at. Frequent accidents occur at these *battues*, which afford but poor sport according to English ideas. The cultivation of the citron seemed likely to create a new and important export; such, however, has not been the case, the prices of the fruit have fallen so much that the growers in many districts have abandoned that culture, and are now grafting lemons on the trees.

The exportation of *Cangourte* (Anglice, craw-fish) is considerable. The Corsican *Cangourte* is considered the best in the Marseilles market, whither they are principally sent. This crustacean is more esteemed in the south of France than the lobster; it is also more plentiful, the latter being, comparatively speaking, rare. A factory has been recently built near Ajaccio, for extracting oil from the kernels of the olive berry. After the oil has been crushed out of the berry (three different qualities by three different processes) the pulp remaining was usually thrown away, or sometimes used as manure; now it is bought by the owners of the factory, and another quality of oil extracted. Bees-wax is also exported, but, considering the vast extent of ground covered with blossoming shrubs, affording unlimited food for bees, it has not that attention given to it which would render it a matter of much greater commercial importance. The honey, except that collected in early spring, is very bitter, and that made in the autumn is hardly edible, so bitter is it, the bees at that time gathering it principally from the arbutus blossom. Among the shrubs and trees, covering the mountain sides, grows the white heath in great luxuriance, becoming sometimes almost a tree, and of late years the source of a lucrative industry. The roots dry up, are cut into rough forms of tobacco pipes by circular saws worked by the water-power of the mountain streams, and sent in sacks to France, and thence to America, to be eventually worked into what are called briar-root pipes; a corruption, it is believed of *bruyère*, the French for heath.

Corsica has for ages had a bad reputation for asassination or vendetta crimes. In 1852, the right of carrying arms by the peasants was suppressed; it was restored in 1867; since then there has been an increase of crime. It seems that it is the new generation that has taken to settle its disputes *more antiquo*, the older men having apparently abandoned, to a great extent, the national custom of shooting or poignarding those who were obnoxious to them, during the suppression of the *porte d'armes*. The Consul-General has lately been urging the Government to grant money for the construc- of a railroad from Ajaccio to Bastia. It would seem that it is likely that this undertaking would soon be commenced; should it be so, there is no doubt but that increased prosperity will be the result.

CORRESPONDENCE.

THE RAPIEFF ELECTRIC LIGHT.

There is an error on page 35 of the report, in your last issue, of my remarks at Mr. Shoolbred's lecture at the Society of Arts, on the 4th inst. As the error may cause inconvenience at the *Times* office, I shall be glad if, in your next issue, you will kindly make the correction which I feel to be necessary. What I said was that "on application to me, at 25, Abchurch-lane, permission could be obtained for visitors to see the light in operation at the *Times* office, by the kindness and courtesy of the proprietary of that journal, and that the permission was granted for Wednesday and Friday evenings." R. Applegarth.

The Electric Lighting Works,
25, Abchurch-lane, Lombard-street, E.C.
December 9th, 1878.

GENERAL NOTES.

The Telephone in America.—The Bell Telephone Company, says the *Electrician*, has placed on the market about 20,000 telephones, and is now making over 400 per week. Telephones were first used only on private lines; but, in the spring of 1877, Mr. Coy, of New Haven, agent of the Bell

Telephone Company, devised the exchange system. Lines radiate from a central office to the houses and offices of the subscribers; and subscribers put in connection through the central office with any other subscriber can at pleasure carry on private conversation. The great advantages of such a system are evident on slight examination. It has already been introduced into all the principal cities of the country, and is destined to produce a great change in the method of doing business in cities, as the telegraph has between more distant points. Many private lines of 10, 15, and 20 miles in length are already in operation, and there seems to be no practical difficulty in connecting, by telephone lines, places several hundred miles apart.

Duplexing the Atlantic Cable.—Mr. J. B. Stearns is now at Valentia, having just crossed over from Heart's Content, where he has been carrying on a series of experiments with the object of duplexing the Atlantic cable. He has been so successful that he expects to have finished his work at the cable by the end of the year. As long ago as last May he obtained a perfect balance on the mirror, but the recorder is more difficult to work duplex than the mirror. He has now, however, succeeded in obtaining a balance with the recorder which, from specimens brought to England, appears practically perfect. Some of Mr. Stearns's specimens show the ordinary local vibrations, or "laterals" as they are termed, which occur alike in ordinary working and in duplex. These vary greatly, being sometimes very strong, and sometimes entirely absent. According to the results obtained on the Eastern companies' cables, which have been duplexed by using Muirhead's condensers, the working capacity of cables is increased about 70 per cent.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

The following arrangements for the Wednesday evening before Christmas have been made:—

December 18.—"Science Teaching in Elementary Schools." by Dr. J. H. Gladstone, F.R.S.

Indian Section.

The meetings of this Section will take place on the following Friday Evenings, at Eight o'clock:—

January 17, 31, February 21, March 7, April 4, and May 2.

African Section.

The meetings of this Section will take place on the following Tuesday Evenings, at Eight o'clock:—

January 21, February 4, March 18, April 1 and 29, May 27.

Chemical Section.

The meetings of this Section will take place on the following Thursday Evenings at Eight o'clock:—

January 23, February 13, March 13 and 27, April 24, May 22.

Cantor Lectures.

Monday Evenings, at Eight o'clock. First Course, on "Mathematical Instruments." Six Lectures, by Mr. W. Mattieu Williams. The fourth lecture of the course will be given next Monday, and the two remaining after the Christmas holidays.

Lecture IV.—December 16, 1878.

The altitude and azimuth instrument—The plane table—The prismatic compass and miner's dial—The surveying cross and optical square—The mural quadrant—Hadley's quadrant—The sextant—Troughton's reflecting circle—The artificial horizon—The goniometer—The transit telescope—The geometrical uses of the clock and chronometer—The equatorial telescope. *Instruments for Levelling, and the Direct Measurement of Altitudes.*—Simple levels without telescopes—The Y level—The dumpy level—Other forms of level—Levelling staves—The mountain barometer—The aneroid barometer. *Instruments for Measuring and Rectifying Curvature.*—The straight-edge and surface-plate—Sights—How to walk straight—The tripod micrometer and the measurement of curvature—The dip sector.

MEETINGS FOR THE ENSUING WEEK.

Mon.... **SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. W. Mattieu Williams, "Mathematical Instruments." (Lecture IV.)
British Architects, 9, Conduit-street, W., 8 p.m. 1. Adjourned discussion on Lieut. Conder's paper, "The High Sanctuary at Jerusalem." 9.30 p.m. 2. Capt. Richard Francis Burton, "Remains of Buildings in Midian."
Medical, 11, Chandos-street, W., 8.30 p.m.
Asiatic, 22, Albemarle-street, W., 3 p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Prof. Judd, "The History of the Formation of the Alps, as Illustrating the Vastness of Geological Time."

Tues. ...Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Annual General Meeting.
Statistical, Somerset-house-terrace, Strand, W.C., 7¾ p.m. 1. Report by Dr. Mouat, Foreign Secretary, on the Demographic Congress, and on the International Statistical Congress, both held in Paris; and on the International Penitentiary Congress, held in Stockholm. 2. Discussion on "The Best Form of Statistical Annual for International Purposes."
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.
Royal Colonial, the "Pall Mall," 14, Regent-street, S.W., 8 p.m. Signor L. M. D'Albertis, "New Guinea: its Fitness for Colonisation."

Wed. ...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Dr. J. H. Gladstone, "Science Teaching in Elementary Schools."
Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. C. Chambers, "Abstract of the Meteorology of the Bombay Presidency." 2. Captain William Watson, "Experiments with Lowne's Anemometer." 3. J. Campbell, Staff-Surgeon, R.N., "Meteorology of Bangkok, Siam." 4. Mr. Kaufmann I. Marks, "Results of Meteorological Observations taken at Calvinia, South Africa."
Geological, Burlington-house, W., 8. p.m. 1. Prof. A. Leith Adams, "Remains of Mastodon and other Vertebrata of the Miocene Beds of the Maltese Islands." 2. Prof. H. G. Seeley, "Dinosauria of the Cambridge Greensand." Parts 1-6.
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Captain R. F. Burton, "The Ogham and Mushiggar Character."

Thurs. Royal, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W., 8 p.m. 1. Mr. W. Mansell Weale, "Note on South African Orchids." 2. Mr. Sylvanus Hanley, "Descriptions of Rare Shells."
Chemical, Burlington-house, W., 8 p.m. 1. Dr. Gladstone and Mr. Tribe, "Researches on the Action of the Copper-Zinc Couple on Organic Compounds." 2. Dr. Debus, "The Formula of Glyoxylic Acid." 3. Mr. T. Wills, "The Production of Oxides of Nitrogen by the Electric arc in Air." 4. Messrs. S. Siguira and C. F. Cross, "Baric Periodate." 5. Dr. Humpidge and Mr. Burney, "Erbium and Yttrium."
London Institution, Finsbury-circus, E.C., 7 p.m. Mr. F. Harrison, "The Abuse of Books."
Zoological, 11, Hanover-square, W., 4 p.m.
Philosophical Club, Willis's-rooms, St. James's, S.W., 6½ p.m.

Fri.......Philological, University College, W.C., 8 p.m.

JOURNAL OF THE SOCIETY OF ARTS.

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FRIDAY, DECEMBER 20, 1878.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

JUVENILE LECTURES.

The usual short course of lectures adapted for a juvenile audience will be given by Mr. W. R. S. Ralston, M.A., on "The Mythology of Fairy Tales." The dates for the lectures will be Friday, the 3rd, and Friday, the 10th of January next. The lectures will commence at seven o'clock. As the number of seats is limited, admission will be by ticket only, and when sufficient tickets have been issued to fill the Room, the issue will be discontinued. The tickets will be supplied strictly in the order in which the applications are received. Subject to these conditions, each member is entitled to a ticket admitting two children and one adult. The tickets are now in course of issue, and members requiring them are requested to make application to the Secretary at once. At present about two-thirds of the available number of tickets have been issued, and those Members who require them are recommended to apply immediately, as the list will probably have to be closed in a few days.

INDIA COMMITTEE.

A meeting of the Committee of the Indian Section was held on Tuesday, the 10th inst., at 4 o'clock. Present—Mr. Hyde Clarke (in the chair), Dr. Birdwood, C.S.I., Mr. Briggs, Mr. Cassels, Mr. Hendriks, Mr. Maitland, Mr. J. T. Wood, Mr. Le Neve Foster, Secretary, and Col. Hardy, Secretary for the Indian Section. The programme of papers to be read during the present session was discussed and decided, and it was agreed that the first evening allotted to this Section, instead of the 31st January, 1879, as previously arranged, should be Friday, 17th January, when the paper read will be by Mr. Black, of the India-office, on "Affghanistan." Colonel Yule, C.B., presiding.

FIFTH ORDINARY MEETING.

Wednesday, December 18th, 1878; R. J. Mann, M.D., F.R.C.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Baynes, Donald, Forest-lodge, West-hill, Wandsworth, S.W.
Day, Lewis F., 13, Mecklenburgh-square, W.C.
Powell, William, Springfield-villa, Leeds.
Roberts, Abraham Francis, 96, Ladbroke-grove-road, Notting-hill, W.
Spencer, Earl, K.G., Spencer-house, St. James's-place, S.W., and Althorp-park, Northampton.

The following candidates were balloted for and duly elected members of the Society:—

Burchell, William, 24, Red Lion-square, W.C., and 46, Gloucester-crescent, W.
Clemence, John, jun., 9, Duke-street, Adelphi, W.C.
Dasent, Sir George Webbe, D.C.L., Belgrave-mansions, Grosvenor-gardens, S.W.
Harrison, Alfred, 3, Havelock-terrace, Sunderland.
Kilvington, William, Sunderland Engine Works, Sunderland.
Newton, John, Manor Works, Rotherhithe, S.E.
Pulvermacher, Isaac L., 194, Regent-street, W.
Turnbull, Alexander, 192, New City-road, Glasgow.
Whiting, Henry Gothwicke, 48, Colveston-crescent, West Hackney, E., and 46, Queen Victoria-street, E.C.

And as Honorary Corresponding Member:—

De Carranza, Commodore Don José, Royal Spanish Naval Commission, 57, Gracechurch-street, E.C.

The paper read was—

SCIENCE TEACHING IN ELEMENTARY SCHOOLS.

By Dr. Gladstone, F.R.S.
Member of the London School Board.

On entering on the subject of Science Teaching in Elementary Schools, I think I may fairly assume that my audience are agreed with me on two points; first, that it is not good that poor children should go forth into the world in gross ignorance of the material objects among which they must always live and work; secondly, that it is far from desirable to try to make scientific men and women of boys and girls of 12 and 13 years of age.

Bearing these two postulates in mind, I wish to define the word science in the title of my paper, as such, and only such, a knowledge of the objects and forces of nature as is suited to the capacity of a child, and is likely to be of service in future life. I mean by it what the Germans call Naturkunde, but which cannot be adequately expressed by any English word. By science teaching, I do not mean what it would imply in our universities, nor yet what is understood by that term at South Kensington, but merely instruction in the common facts and common modes of action of nature. This kind of science teaching stands in much the same relation to what is usually called natural science as the reading lessons and grammar do to literature; as arithmetic does to mathematics; or as the drawing and singing taught in our schools do to art. I would claim for it a place in the education of every child on two distinct grounds;

the usefulness of the knowledge conveyed, and its value in training the mind.

It seems scarcely necessary to prove the first of these. This earth is our dwelling place, from the cradle to the grave; our bodies are the complicated machines, so wonderfully made, by which every action of ours is performed; the sun, clouds, and atmosphere influence us every day; the animal, vegetable, and mineral kingdoms are ready to yield us their supplies; and the great mechanical and chemical forces, with heat, light, and electricity, are ready to be our servants if we do not allow them to become our masters. Every man also in his handicraft or trade, as well as every woman in her domestic duties, has to deal with some facts and objects of nature specially connected with them.

The value of natural science in its training of the mind consists in its being the means of drawing out the powers of the five senses with which each individual is endowed. Other studies may be better fitted to improve the memory, to develop the logical faculty, to cultivate the taste, or to elevate the moral character. The special value of natural science, even in its most rudimentary forms, is to draw forth the powers of perception and observation, and to train the judgment in the pursuit of truth.

I propose to give a sketch of how the matter stands at present, and then, of what improvements appear to me desirable. One of my objects in bringing the subject before this Society is to elicit the opinions of others, and any criticisms or suggestions which may be made to me, either in the discussion or privately, will receive my most careful attention.

The Present State of the Question.

Twenty years ago, there was more of this kind of teaching in our national elementary schools than there is at present. The Revised Code of 1861 introduced the individual examination of scholars for the Government grant, and while this was a salutary and necessary reform, it had the disadvantage that it makes it so incumbent on every teacher to work up every child in his class in reading, writing, and arithmetic, the mere tools of knowledge, that they have little time or energy to give to more liberal studies. From the great Exhibitions held in our own and other countries, and from many other circumstances, there arose a feeling in the public mind that our artisans must have a better and more practical education if our manufactures are to compete with those of continental nations; and the new Code, which is issued annually by the Education Department, shows an increasing disposition to favour the introduction of scientific or semi-scientific studies. Nevertheless, the present Code does not recognise anything that can be called science teaching until the 4th Standard, unless, perhaps, a little physical geography in the 2nd, and a child can scarcely attain to the 4th Standard until it is 10 years of age, and the great majority of our elementary scholars never reach it at all. Moreover, the teaching of science in the upper standards is never enforced, and only permitted if certain other conditions are fulfilled. There still survive, however, in most of our infant schools, the old object lessons, while diagrams of beasts and trees generally relieve the walls of our school-rooms, and afford the subject of occasional lessons. These, however, are not in any way mentioned in the Code.

The training colleges established in connection with the large educational societies were not slow in taking advantage of the offers of the Government and forming science classes. In this way most of those young men and young women who enter the profession as elementary teachers go up for the examination of the Science and Art Department and take their elementary or advanced certificates. From the last report of the Committee of Council on Education it would appear that in 1877 the following number of teachers passed in the various science subjects specified:—

Subject.	Male.		Female.	
	Elementary.	Advanced.	Elementary.	Advanced.
Animal Physiology ..	321	422	229	150
Acoustics, Light and Heat	330	337	43	9
Magnetism and Electricity	281	222	..	..
Theoretical Mechanics	279	7	..	..
Physical Geography, or Physiography ..	31	124	34	92
Inorganic Chemistry	143	23	..	..
Geology	55	23	..	..
Elementary Botany ..	2	4	273	90

It would appear from this that animal physiology, which really includes the laws of health, is a favourite subject with both male and female teachers, and of its utility there can be no doubt. The great forces of nature, as shown in light, heat, sound, and electricity, appear to have many attractions for the gentlemen, and botany for the ladies. Chemistry appears to be comparatively rarely taken up, although there are good laboratories at the training colleges of Westminster and the Borough-road, and probably in other places. The Home and Colonial School Society, which especially devotes its attention to the training of mistresses for infant schools, retains, I believe, its pre-eminence for the teaching of object lessons in all their variety. There are several other institutions also which aid pupil-teachers, or acting teachers, in the acquisition of scientific subjects, among which may be especially mentioned St. Thomas Charterhouse Schools of Science, in the Goswell-road, started by the Rev. John Rodgers. At present it has about 400 students. The Science and Art Department have also arranged that acting teachers should attend practical classes in the summer time at the Schools of Science, South Kensington. These classes last three weeks, the instruction is given gratuitously, and is frequently taken advantage of even by students from Ireland. Mechanics, botany, chemistry, and physics are amongst the subjects taught. In Professor Guthrie's laboratory they learn to make simple but very efficient apparatus at scarcely any expense; and in Professor Frankland's laboratory they learn simple analysis.

Turning to that peculiarly English institution,

the pupil-teachers, we find that the Government Code does not require any science as an essential part of their instruction, but at their scholarship examination for admission to the training school, additional marks are given to any candidate who has taken a first-class in the elementary stage, or passed in the advanced stage of one of the following subjects: — Mechanics, chemistry, animal physiology, acoustics, light and heat, magnetism and electricity, physiography, and botany.

The following table shows the number of male and female pupil-teachers who obtained certificates in the various subjects according to the last report:—

Subjects.	Number of Passers.	
	Males.	Females.
Theoretical Mechanics....	13	..
Applied Mechanics	2	..
Acoustics, Light and Heat	121	11
Inorganic Chemistry	106	7
Organic Chemistry	2	..
Magnetism and Electricity	207	48
Animal Physiology	109	18
Elementary Botany	7	9
Physical Geography......	253	80
Physiography	1	..

Turning from the teachers to the scholars, we find that in the three upper standards the following are included among "the specific subjects of secular instruction": — Mechanics, animal physiology, physical geography, botany, and domestic economy, but only two of these can be taken up by the same child. The teaching of these subjects is encouraged by a grant of 4s. per subject for every scholar who passes a satisfactory examination in not more than two of them, and, if the scholar be a girl, one of these must be domestic economy. But any scholar who has previously passed in standard six may be examined in three subjects. In order to ensure these specific subjects not being unduly attended to, no grant is given unless 75 per cent. of the scholars presented pass their standard examination. Mechanics, as defined in the Code, includes some of the fundamental physical conceptions of matter and its properties, also of force and the conservation of energy, in addition to the mechanical powers. Animal physiology is really a description of the human body and some of its principal functions. Physical geography includes, not merely what is usually so called, but the elements of meteorology and an explanation of the phenomena of day and night, the seasons, the changes of the moon, &c. Botany is not so much to be taught as a descriptive science, but rather the general principles and the different structures of plants are to be illustrated. Domestic economy is wide in its significance, including food, clothing, ventilation, washing, the rules of health, and even cottage income and expenditure. It appears rather as a practical art, but should be founded of course on scientific principles. The Code adds this important note:—"It is intended that the instruction of the scholars in the science subjects shall be given mainly by experiment and illustration, and, in the case of physical geography, by observations of the phenomena presented in their own neighbourhood. If these subjects are taught to children by definition and verbal description, instead of by making them exercise their own power of observation, they will be worthless as means of education."

Out of the three million scholars in the inspected elementary day-schools of England and Wales, it appears that only the following numbers passed in these subjects:—

Description of School.	Mechanics	Animal Physiology.	Physical Geography.	Botany.	Domestic Economy.
Church Schools..	506	5,001	9,329	403	5,404
British, Wesleyan, &c.	58	3,597	4,771	276	1,915
Roman Catholic..	..	1	122	..	250
School Board....	20	4,433	4,714	234	3,350
Total	584	13,032	18,936	913	10,919

This shows less than one pass in a science subject among 60 children.

It will be observed that these subjects do not include any description of animals or minerals, nor the least idea of chemistry. They are to be studied also, if studied at all, concurrently with many other subjects, and no preparatory instruction has any encouragement by a Government grant. Nevertheless, in our infant schools object lessons are generally given, sometimes by means of diagrams, sometimes by means of the objects themselves, either collected by the children or supplied in boxes sold for the purpose. These object lessons, no doubt, are sometimes intelligently and carefully given, but, as a rule, it is to feared that they are not prepared with any care beforehand; they are left to pupil-teachers, who know little themselves of the common facts of nature, and have little command of simple but picturesque language. It very rarely happens that there is any order or system in the instruction, or that it leads up to anything in the higher departments of the school. In some cases the teachers make little experiments, but, I believe, as a rule, the object is simply held up to the class, talked about, and put into the box again.

This instruction, irregular and imperfect as it may be, does, however, interest the little children in surrounding objects, and arouse their powers of preception. But when they arrive at the first, second, and third standards their position is less fortunate. Miscellaneous information is, no doubt, given in their reading books, but there is rarely any provision for carrying on the object lessons of their tender years, or for preparing them for the more scientific subjects which they may some day reach in the higher classes of the school. It thus appears that, in the elementary schools of our country, any instruction in the common facts of nature is likely to be very meagre and must be very limited.

Yet there is an impression abroad that our ele-

mentary schools are attempting a high education and teaching all sorts of science. This idea found its fullest and most authoritative expression in the introductory address of Lord Norton at the recent Social Science Congress at Cheltenham. He said that "of 26,465 scholars presented in the sixth, or highest standard, 2,291 failed in reading, 6,681 in writing, and 12,000 in arithmetic; a large number of whom were by the conditions of that standard being crammed in what are called 'specified secular subjects' in the fourth schedule to the Code and dabbling in botany, animal physiology, &c." This appears absurd on the face of it, for, as the Hon. George Brodrick showed at the time, no child is likely to be presented in the sixth standard who has not already become tolerably proficient in reading, writing, and arithmetic in the lower standards, and, in point of fact, adopting the figures of the last return, out of 31,967 children presented in the sixth standard in England and Wales, 3,224 failed to read with fluency and expression, and to repeat their proper quantity of prose or poetry; 5,864 failed to write a short theme or letter with good composition, spelling, grammar, and handwriting; while 13,824 failed to show a sufficient acquaintance with proportion, vulgar and decimal fractions. As to their being crammed with specific subjects, out of 252,000 which were examined in the three higher standards, only about one-sixth took any of them, and it is notorious that the schools where the largest per-centage of failures occur are not those that undertake the higher branches.

DESIRED IMPROVEMENTS.

It may be desirable to consider how these subjects are treated in those countries which have made the greatest progress, both in the theory and practice of primary education. The most important of these is, probably, Germany; and, as my information is more complete about that country, I shall confine my remarks to it. Besides programmes of education published by some of the States, I have received letters from Dr. Siegel, in Austria; Dr. E. Loew, of Berlin; Dr. Mahraun, of Hanover; the Rev. E. Grein, of Hesse; the Rev. G. Specht, of Baden; J. Wickel, of Nassau; F. Schroeder, of Brunswick; and the celebrated Dr. Döllinger, of Bavaria. As a general rule, from the information received from these gentlemen, it would appear that some knowledge of the ordinary facts of nature is universally given in the elementary schools. The age at which it commences, however, varies from seven in Austria to twelve in Bavaria; it is usually about nine or ten. Two hours a week is pretty uniformly devoted to this subject; it is taught by means of diagrams and pictures, according to all my correspondents, and frequently by means of small collections illustrating the animal, vegetable, and mineral kingdoms, and sometimes simple apparatus for the performance of experiments in chemistry or physics. In some States it seems to be the habit for teachers to prepare the lessons from books used solely by themselves; in other cases each pupil has his *leitfaden*, or some other rudimentary book, in his hands. To speak more particularly of the kingdom of Wurtemburg, the subjects of instruction are divided into religion, language, arithmetic, facts (*realien*), singing, and drawing. "Facts" include geography, natural science, biology, and history. The facts of nature are taught by means of object lessons, beginning with the things nearest to the scholar, the school, his home, common animals, the garden, water, sky, &c. This instruction lasts for a year or more, and introduces the scholar to the lessons on natural science and natural history which are to be found in the reading-book, and which deal with a large variety of matters connected with the mineral, vegetable, and animal kingdoms, illustrated by pictures, and occasionally specimens, and which continue up to the end of their studies.

The French, who have lately been making great progress in their primary education, are largely introducing *leçons des choses*, and last Whitsuntide an object box, containing things illustrative of food, clothing, and household matters, was introduced into the infant schools in Paris.

There are not wanting indications of advance in the same direction in our English schools. The principles of Comenius, Pestalozzi, Fröbel, and other reformers, are making way, admirably simple manuals have been published, and the demand for the technical education of our artisans will necessitate the introduction of more preliminary teaching of nature in our common schools. The School Board for London encourages those teachers who have science certificates, by giving them the preference when they apply for situations, and also by considering the matter in their salaries. The Board originally laid down as among the essential subjects of instruction "systematised object lessons, embracing in the six school years a course of elementary instruction in physical science, and serving as an introduction to the science examinations which are conducted by the Science and Art Department," and, for infant schools, "object lessons of a simple character." But it was one thing to lay down this as essential, and another to attain it in practice. The Board, however, has lately shown its determination to carry it out, if possible, by inserting in the code of regulations for the guidance of managers and teachers the following Scheme for object teaching:—

INFANTS' SCHOOL (NON-STANDARD CHILDREN).

Aim.—To develop in the children's minds an interest in the things round and about them; to teach the use of all the senses, and form habits of observation; to impart a correct knowledge of the commonest things; to increase the infants' vocabulary and power of expressing themselves.

Subjects of Instruction.—Objects illustrative of the three kingdoms of nature—animals, plants, and minerals, especially such as the children meet with commonly in their ordinary life. The different parts, qualities, and uses of these objects.

Means.—Diagrams; objects procured by the teacher or supplied from the store, and a small case of apparatus to enable the teacher to perform the simplest operations necessary to illustrate the properties of the objects. Children are to be encouraged to bring the needful objects both in this and subsequent stages.

STANDARD I.

Aim.—To carry on the previous training, leading also to the exercise of the judgment, in showing the relations of the different parts of bodies, and how their different qualities fit them for the uses to which they are applied.

Subjects of Instruction.—A somewhat more extended

series of objects, with fuller information as to the qualities, uses, and history of common things.

Means.—Diagrams of animated nature, &c., classified—small cabinet of objects, classified for purpose of comparison, with simple apparatus as before.

Standards II. and III.

Aim.—To lead up from the previous training to the "specific subjects" of the Code.

Subjects of Instruction.—Series of objects illustrating the most important manufactures. Geographical distribution of products and means of procuring them. Objects for teaching the fundamental notions of matter and force.

Means.—Diagrams—same small cabinet as before. Loan collections of objects tracing the raw material to the final product (such as cotton, flax, silk, leather, wool, iron, and clay).

Standards IV to VI.

Aim.—To teach the "specific subjects" of the Code.

Subjects of Instruction.—One at least of the following:—

Mechanics.	Taught by diagrams and	working models (on loan).
Physiology.	ditto	models (on loan).
Physical Geography.	ditto	maps and experiment.
Botany.	ditto	specimens and models (on loan).
Domestic Economy	ditto	demonstrations and experiment.

In carrying out any such plan of instruction in the common facts of nature I may be allowed to express a hope that the instruction given will be, as far as possible,

I.—*Within the scope of the child's experience*—Thus I have frequently remarked that a fine diagram of a lion is hung up in the infant schools, and once in the babies' room the teacher in charge told me it was a great favourite—the little ones called it a dog; and I thought it would have been much better if it had been really the picture of a dog. It is a great point also that the objects explained to the children should be generally such things as they can themselves bring to the teacher, a practice which is always found to give additional interest to the lesson.

2. *Experimentally illustrated.*—Thus, the children should, in the first instance, be encouraged to feel and smell, and perhaps taste, the object, and, in many cases, it should be melted or burnt, or taken to pieces in their presence. In their future studies, mechanics should of course be taught by actually showing the different forces at work; and the various points of domestic economy should always be practically illustrated.

3. *Continuous.*—There is an evident advantage if the course of instruction leads up from the baby-room to the highest class in the school. Thus, to take merely one instance, starch might be first shown to the infants as a white powder with certain properties, afterwards the preparation of starch should be shown from potatoes or flour, and then its peculiar structure may be exhibited by a magnifying lens, and the chemical change which it undergoes when heated with water, exhibited. This will lead on to the recognition of its importance in the economy of plants, and will also render perfectly intelligible to the girl its use in the stiffening of textile fabrics, and the part it plays in the baking of bread or the boiling of vegetables.

4. *With reference to Practical Life.*—It is evident that the instruction bearing upon our bodily health, or the salubrity of our dwellings, would be valuable for every one, whether having charge of others or only of themselves. There are many matters connected with the mechanical and chemical arts which could scarcely fail to be of service in any future avocation. When technical schools in England have become common, their requirements will doubtless influence the particular line of study in our elementary schools, but the main phenomena around us must always form the foundation for any subsequent study.

It is to be hoped that the Education Department will see its way to give some encouragement to systematised object lessons, especially in the lower standards. One means of doing this would be to adopt the plan which has been brought forward by Sir John Lubbock in Parliament, that elementary science, or, as Dr. Lyon Playfair more appropriately called it, the "knowledge of common things," should take its place among the class subjects—history, geography, and grammar, in the second and third standards. This will, however, depend, in a great measure, on how it is taken up by the general public; and I would commend this important matter to the consideration of all those who take practical interest in the primary education of the mass of their fellow countrymen.

DISCUSSION.

The Chairman said this question was a very important one. One object of the paper appeared to be to remove the erroneous notion of there being a sort of cramming in scientific matters going on in the immature mind. He knew a little himself about what was being done in these matters, and the feeling in his mind was that there was very much less doing in science in Board schools than some people thought. Still, assuming it to be true that elementary science was an important branch of public education, there was nothing at all to be afraid of. Less than half a century ago science teaching was unknown in the great schools and universities of England; and when Prince Albert, taking an interest in the matter—more especially in connection with higher schools—consulted the great authorities, he went amongst others to Dr. Whewell, who was at that time a great authority on science, and asked him what he thought of the introduction of it as a branch of the ordinary work in universities. His answer, as far as he remembered, was that he saw no objection to it, always providing that no pure physical science should be taught unless it was one century old. Comparing that state of things with the present, the difference was almost as great as would be seen by anyone going down the Thames Embankment, and comparing the poor yellow eclipsed gaslight with that given by the Jablochkoff candles. One very inadequate reason that so little was at present done in elementary schools in this direction must be known to all who had had to deal with those schools, viz., the early age at which children left them, and the extreme pressure there was from the manner in which elementary routine subjects were pressed on the minds of the pupils. Taking the returns before them, it appeared that physical geography stood at the head of the science subjects taken up, and although the reason for this was not so very evident, it was no doubt that for many years geography had been one of the ordinary branches of education, and therefore physical geography was taken up from its real or supposed

connection with it. For some years of his life he had had to do with public instruction in one of the colonies, and when he began he was very sanguine as to the introduction of science. He was convinced that it could be used for mental training more powerfully than many of the ordinary subjects, such as languages for instance, but after many years' experience he came out of the conflict with the practical conclusion, that in all elementary schools the essential thing to do was to teach as strongly and soundly as possible the rudimentary matters of education. When children went away from school very young, as they did at present in England, it was scarcely possible to do more than to give this elementary education soundly and well. In many cases of schools where science was attempted to be taught, he found it was more for the ambition of the teacher than the advantage of the child. It need not necessarily be so, but the result of his observations had led him to that conclusion. The proper functions of science in elementary education he considered were two-fold. In the first place, to open vistas of various kinds in the future. While you were training the mind of a young child, if you could drop into it the idea that there were great fields of interesting observations scattered around in nature, the appetite might be formed to inquire, and think, and go into a little investigation of its own, and in that way science would do an infinite amount of good, even in elementary schools. When you came to the higher standards you could do something more, and undoubtedly use science very powerfully indeed as a means of intellectual training. Experimental work was of the highest importance, and the construction of a little apparatus, like that which they saw on the table, was science of the highest order, for the training thus given to the eye, the hand, and the mind, could not fail to give a sound knowledge of the principles concerned. He also looked upon diagrams as an enormous aid to teaching, and for general use he preferred them to the objects themselves. When you came to such teaching as animal physiology, to take an illustration, if it were an object to give an idea of the influence and action of the liver in human bodies, which it was important for everyone to know, he would venture to say that a skilled anatomist, taking the liver of an animal and manipulating it before a mixed class of children, could convey scarcely any idea to them; but with a well drawn and well coloured diagram, showing the various veins and blood vessels, he would be able, in a single half-hour to give a very good idea. Many of the diagrams round the wall were very admirable, but there was a radical fault in most of them for the objects for which they were designed, viz., they were too crowded, by having, for the sake of economy, two many subjects in one diagram. He would rather take a diagram and draw from it on the blackboard, so that the children could see only the thing he wished them to look at, than attempt to teach by such complicated diagrams as many he saw before him.

Mr. J. G. Fitch, M.A., said that, though elementary science teaching was a matter constantly under his observation, he was no authority upon the subject, and would only venture one remark. His experience proved to him that, with regard to the matter of illustration, whether by diagram or model, the very best he ever saw were made *ad hoc* by the teacher himself, adapted to his own lesson—his own little models in clay or sand for teaching physical geography, or the illustrations of trade and manufactures which he had got the children to bring him themselves. Beautiful and interesting as the diagrams and models now exhibited were—and he would not say a word against them—he was a little jealous of them, as tending to discourage the inventive powers of the teachers themselves.

Mr. G. C. T. Bartley remarked that, though there was a great deal yet to do, yet, on looking back 20 years, it would be seen that very much had been done. When he was first acquainted with science schools, there was some little jealousy about men going into them. At Manchester, for instance, he had found that, to a certain extent, a workman lost caste by attending science classes, but that was all gone now. He quite agreed with Mr. Fitch that the best illustrations were to be found in the school-room itself. At one time, when he was a guardian of the poor, he took a great deal of interest in the workhouse schools, and on going in there one day, and asking the boys if they could point out a piece of iron, not one of them could do so, though there was an iron stove in front of them. Having in vain asked a few other questions with regard to common tools, he at last asked what a spade was, and only one boy could answer, and he said it was something "to dig taturs with." It was often said that children had not time to learn these things, but he believed this was to a great extent a question of thrift and economy of time, and that, by judicious varyings of the lessons, time might be found for a good deal. He did not see why that discussion should be limited to the elementary schools, for his experience was that there was quite as much need for science teaching in middle-class schools as in elementary, and even in universities there was room for improvement.

Prof. Tennant said he had been at work in the school-room for 50 years, and for 25 in a Sunday-school in Drury-lane; and in the latter place he had always found much interest taken in lessons on common objects, such as minerals, the ores of lead, copper, silver, or anything of the kind. It was astonishing the amount of knowledge children would acquire in this way. The progress made in the teaching of science during the last 50 years was astonishing. Diagrams were marvellously perfect; though he had a friend, very clever at preparing them, who would always make everything the same size, whether a butterfly or a whale, and of course the children could have no idea of the comparative size of the objects. In London there were many facilities for teaching zoology; at the Zoological Gardens, for instance, to which free admission for children and a teacher could be obtained on certain days, when more knowledge could be obtained in a short time than in many hours by diagrams and description. Geography could also be taught at same the time. The museums, too, were well adapted for teaching purposes, though not so much so as on the Continent, were it was the practice to put labels on the specimens, stating where they came from. Some twenty-five years ago, the Society for Promoting Christian Knowledge issued a number of scientific charts—the most perfect of their kind he had seen—on a small scale, at a very low price; they sunk about £1,500 in producing them, and sold them at the cost of the paper and printing. He remembered showing them to Mr. Stephenson, the engineer, who was astonished at the price, and it appeared that he made his will soon after, and left the society £2,000. He had had the great advantage of being a student of the Mechanics' Institution, under Dr. Birkbeck; and when he was first called upon to teach the children of the nobility, he used to try the children of the poor in Drury-lane, because if he could get them to understand what he had to say with regard to minerals, the others would; but he found the poor children quite as intelligent, and as apt to receive instruction as those of the rich, especially girls. As a rule, a girl learned more in three lessons than a boy in four. Unfortunately, if they once got hold of an error, it was very difficult to get rid of it.

Mr. F. Drew said he must take it for granted that science teaching was desirable, and would therefore only deal with the means. As regards the higher parts of this teaching, only occasionally reached by the higher pupils, they had a most admirable synopsis in the "Science and Art Directory." The numbers stated,

however, showed to how small an extent it was taken advantage of. There were two reasons for this, the one on which he should lay most stress being that, to begin the study of science without any previous preparation was very up-hill work, and this was what stood in the way of the teachers themselves. They took up a science subject for the first time to get a certificate, and they found the nomenclature and the very fundamental ideas quite new to them. Physical geography, for instance, required a knowledge of parts of a great many sciences, and a considerable number of facts taken from different branches. The next step, therefore, in science teaching, must be to go lower down, and teach it in some different way. He could not help thinking that the London School Board had hit the right nail on the head in going back to object lessons. This, properly worked, with a scientific aim in view, would make an admirable method of teaching things useful at the time, and which would lead up to a more systematic teaching of science afterwards. You should teach not merely that which was useful and pleasant at the time, but choose a subject the knowledge of whose properties would help you in the next step towards an acquaintance with the science upon which it bore. There were many chemical and physical properties which could be easily described and illustrated by common objects, such as the one mentioned by Dr. Gladstone. He could not say at what age it was possible to begin, but the earlier the better, and the earlier you could take the next step into science proper. There was no lack of objects, a knowledge of which was thus doubly useful, for instance, the minerals mentioned by Prof. Tennant, or the metals which came from them. Another great advantage was, that it increased the child's vocabulary. They wanted something not only to talk, but to read about; the two things ought to go together, and no one should be deterred by the fear of the hard names of science, because they should not be taught until the things they represented had been shown. When the children had seen the thing they would want a name to fit to it; and one point about these scientific names was that they were generally spelt more phonetically than ordinary English words, and were thus more easily read. He agreed with Mr. Fitch, that they should not use too complicated diagrams, but at the same time the teacher should not be confined to objects close at hand. Teachers had not much time to collect objects, and managers of schools might fairly be called upon to aid them. Another point upon which he was not, however, quite clear, was this. He feared that science lectures gave the master a good deal more work than the pupil; and he thought it would be well if the latter had some handbook from which he had to get up a lesson and answer questions. In conclusion, he wished the School Board all success in the efforts which it was making in this direction.

Mr. Alfred Wire said he was a science teacher, and the head master of a large school, and he did his best to teach science by means of object lessons, diagrams, and models made by himself. About four years ago, he was head teacher of a large endowed school which had enormous funds; and when he began science teaching, to his great surprise the local trustee, a clergyman, brought forward a resolution that he should not be allowed to teach science. Some of the trustees were much amused at this idea, and he was glad to say that the resolution was not carried, but he had a grant of £5 to spend in apparatus. It happened one day that a boy brought him a bat, and he was giving a lesson on it, when in came the diocesan inspector; the lesson was put on one side, and the inspector then put some questions in the catechism which the boys did not answer very well. A few days after he received a confidential letter recommending him to leave those science subjects alone, and stick to the elements. He might say that he gave lessons in natural history, zoology, and botany, as far as his knowledge went. One day he told the boys in the class to choose the subject for the next week, and they asked him to give a lesson on the earwig, but he said he could not do that in a week, as he was not acquainted with it, and there was no library in the town, and he had not a book on entomology. At last he found a friend who had a book on the subject, so he went to work, made a large diagram, borrowed a microscope from the doctor, and was wonderfully interested in dissecting the insect, unfolding its magnificent wings, and drawing them to scale on the black-board, and the lesson was one of the most satisfactory he had given. Strange to say, a little while ago the Board passed a resolution that none of the children were to be taught "scientific subjects." As he told one of the members privately, they could not prevent him giving object lessons. One day a member of the Board was present at one of his lessons, and was much pleased with it, saying, that for political reasons the resolution must stand, but they would not interfere with the lessons, only that the children were not to be examined. The figures put forward, therefore, were not altogether correct. There was a good deal more going on in schools than appeared in the registers. Some of the members of his Board were rather obtuse, for he had asked three times for a globe, but could not obtain one. They would spend any amount on maps, but would not give him a globe. Besides the ordinary teaching, he had been accustomed to give lectures to the parents in the evenings for a small fee, devoting the money to the benefit of the children; and he was glad to say he had just received permission to give a course of this kind, the proceeds of which were to be devoted to a school library.

Mr. Christian Mast thought it must be generally acknowledged that science might be taught, even to young children; but with regard to the method, that should be left to a great extent to the teachers. He thought a great want in this country was good reading books, such as were found in Wurtemberg, his native country. He must say, however, they had greatly improved of late. He feared that some who advocated science teaching were doing harm; because they advocated too much and frightened people.

Mr. T. H. Smith said there were many hundreds of teachers who would be glad to teach science more than they did, but unfortunately the children left school too early. It was sad to see children going away to work when they were on the very threshold of that which would do them an immense deal of good if they could only be retained two years longer. He did not think that parents were the only ones responsible, for the authorities ought to encourage them to keep the children at school more than they did; and the Education Department and School Board were not altogether guiltless. The half-time system, he in common with many other teachers, believed to be a bad one, but the School Boards supported it very strongly. He felt that it interfered very much with systematic scientific instruction, and, together with the early age at which children left school, was a very great obstacle.

Mr. Greenwood hoped Dr. Gladstone would not be led away by the remark of Mr. Bartley about thrift in time, and considered that Board schools in London had quite enough overhauling at present. In the first place, they were overhauled by the Government inspector, on whose report depended about 40 per cent. of the teacher's salary; then there was another overhauling in the matter of drawing; then there was drill; and there were so many things of this kind that they were in a constant state of turmoil. As soon as one examination was over they had to prepare for another, and in the next four months he had four to look forward to, and had just passed the examination of the Board.

Mr. Goffin thought many who had spoken knew very

little really of the school-room. He went heartily with Mr. Fitch about the diagrams, which were often quite useless; it was impossible to teach from them. The diagrams of a suction-pipe and a force-pump were practical, but a boy would learn much more from a piece of glass tube and a bit of tow. If they were to have real scientific instruction in this country, they must have men of scientific education as directors; but those whom the Government put in this position knew nothing of science or scientific processes. They went into a school, and asked nonsensical questions, which they expected the children to answer off-hand, though they could not, by any possibility, answer them themselves. They wanted men like Dr. Gladstone, who would go in for experimental science, and who were willing to give their whole energies to it; but these men were kept in the background, and forced to turn to other occupations. The figures on the board were as fallacious as possible. If any one wanted to see scientific instruction carried out, they need not go to the Continent. Prof. Hassfelt, who had been commissioned by the Government of Wurtemberg to visit the schools of England, told him the other day, after witnessing the experiments in a school which he knew well, that the English schools were infinitely superior to the continental; they had no schools there of the class he had just seen, where he could give 40 boys, of less than 14 years of age, any simple salt, and they would find out the acid and the base of which it was composed. Yet there were many people who said you could not teach boys science until they were so old as to be boys no longer. From 20 years' experience he could say that you could introduce science systematically as early as any other subject, no matter what; at 10 as well as 15. The only necessity was for the teacher to know his subject; not like the gentleman to-night, who said he knew nothing about the earwig; such a man could not give a full dose of his subject to his pupils. A thoroughly competent man would take up anything, it might be a pebble from the street, and make an intellectual lesson on it.

The Chairman asked if the school referred to was a middle-class school?

Mr. Goffin said it was a school where a certain number of boys from elementary schools were sent, selected by competition—an endowed school, under the Endowed Schools Commissioners. There were proper apparatus and proper rooms provided.

Mr. Pearsall said that anyone who had visited the Birkbeck Schools some time back would endorse what the last speaker had said. The first men of science in the land had been astonished at the quantity and accuracy of the knowledge there imparted; in fact, Professor Huxley had been converted by it, and, as a consequence, physiology was taught by the Government department. With regard to illustration, he thought immense aid might be obtained from photography, the magic lantern, and the oxy-hydrogen microscope, and any errors with regard to relative sizes could be set right by the teacher. He believed the contest between this country and the Continent was not thoroughly appreciated. In France there were large placards on the walls inviting the public to attend courses in drawing, geometry, singing, &c., free; and he was told that pains were taken in the schools to ascertain what the boys were suited for, and facilities given them for obtaining the instruction necessary for their future calling, so that they stepped from the school into the workshop as intelligent young men. At the recent Exhibition, too, it was very interesting to see groups of workmen taken round the building every day by persons who pointed out and explained to them the different machines and objects. He had an opportunity of seeing this, and he had been specially struck by the intelligent appreciation of what they saw, which was manifested by these workmen.

Dr. Gladstone said he had really nothing to reply to, but he had been favoured with some very valuable supplementary remarks. He could confirm what had been suggested, that the best teachers used the simplest apparatus, and one could often do more with a blackboard than with the most elaborate coloured diagram. At the same time, the higher kind of teaching could not be accomplished without models and diagrams. He sympathised very much with the gentlemen who had spoken—and no doubt many other teachers would agree with him—of the large amount of time which had now to be given to matters which were the subject of Government or other examinations, and he must confess that it was very difficult to get any more work into the time-table. But still, if they ventilated the subject and insisted on its importance, it was quite possible that the individual examinations might be to some extent curtailed, or some subjects might be, to some extent, reduced, as far as the time devoted to them was concerned. One thing, however, he was quite sure of, that not much time was required to give certain interesting object lessons. One hour a week, in two or three short lessons, devoted to this subject, would relieve other drier subjects, and give an interest to the scholars, and intelligent teachers would find that there had been no loss whatever in the general results. He felt it was a matter of immense importance that the teaching of facts of nature should not be confined to the upper standards, for every man had to go forth into the world to work for his living, and to contend with the various forces of nature round about him, and to be constantly affected by the various objects he met with, and many now knew nothing whatever about that which they would have constantly to deal with in their future lives. It was a great pity this should be the case; he hoped that primary education would advance very much more in that direction, and that, in addition to the words and deeds of men being studied in schools, the works of the divine hand would be constantly the subject of lessons to all, and that thus the pupils would not only be much interested, but their minds would be improved, and they would learn much which would be useful to them. He was glad that one gentleman had taken up the subject of what might be done in the higher classes. It seemed rather absurd that children should be expected to enter on science subjects really as science; they wanted their powers of observation quickened while they were very young, and the sooner you began with that kind of lessons the better; by that means you could first wake up the intelligence of little children, and they would go on with habits formed to see and feel everything round about them, to ask questions, and to store their minds with facts which would be useful to them afterwards. He had purposely refrained from saying anything about higher education, because there was abundance of scope in dealing with elementary schools; but the other subject was one of perhaps equal importance, and possibly he or some one else would on some future occasion bring it before the Society.

On the motion of the Chairman, a unanimous vote of thanks was passed to Dr. Gladstone, and the meeting separated.

Sir U. Kay-Shuttleworth, Bart., M.P., writes:—"I am particularly sorry not to hear and support Dr. Gladstone, but I have an engagement at home I cannot put aside. *Natur-kunde*, or the rudimentary facts of nature simply taught in elementary schools, as in Germany, would enliven the work of teachers and children, and develop the intelligence and powers of observation and thought of the latter, and supply a great need in education. I hope the Society of Arts will help Sir J. Lubbock in the motion he will again bring forward this Session, as he did last Session."

MISCELLANEOUS.

REPORT OF THE BOTANIC GARDEN, CALCUTTA.

The annual report of the superintendent of the Royal Botanic Garden, Calcutta, for the year 1877-78, and dated July 10th last, has lately been received. In this report plants of economic interest are largely treated of by Dr. King. Among those of medicinal value ipecacuanha alone claims attention. A number of plants of this important drug have been sent from Calcutta to the Botanic Garden at Singapore, where the climate is stated to be such as should suit it admirably. It is satisfactory to learn that a considerable stock of young ipecacuanha plants is kept on hand at the cinchona plantations ready for issue to any applicant should they be required. On the other hand it is very unsatisfactory to hear Dr. King say that he fears this drug can never be successfully grown as a crop in any part of Bengal, though perfect success has attended the propagation of the plant from root, cuttings, and seed, and it grows luxuriantly under cover. But out of doors the low night temperature of the cold weather proves too severe for it. During the year 26 pounds of the dried root, taken from plants grown in frames at Rungbee, were sent to the medical depôt for use, previous trials having established the excellence of the Sikkim-grown drug.

Regarding plants of commercial interest, those yielding caoutchouc, or india-rubber, claim the first consideration. The seedlings of Para rubber (*Hevea brasiliensis*) received in the beginning of last year, were, it seems, partly retained in the Calcutta garden and partly sent to the cinchona plantation in Sikkim. Several of these plants died during the year, so that 14 only remained, which, however, were reported healthy, and to have grown fairly well. Every care is being taken of them, and Dr. King expresses a hope that he may soon be able to report that they have been increased in number by artificial propagation; former experience, however, has taught the necessity of exercising great care in allowing cuttings to be made until the parent plants have had plenty of time thoroughly to establish themselves. A quantity of Ceara rubber plants, collected in South America, by Mr. Cross, and sent to Calcutta from Kew, were received along with the Para rubbers. It is well known that the seeds of Euphorbiaceous plants generally retain their vitality but a comparatively short time; consequently, about one-third of the plants in this consignment was found, on arrival, to be either dead or in a bad condition; of the remainder, five plants were sent to the cinchona plantation, and the balance retained at Calcutta; one of these latter plants is now three feet high, and the stems vary in height from two to five feet, but they all look more or less weak or lanky, indicating that the climate is too damp for them. This Ceara rubber plant, as has been already shown in the *Journal*, vol. xxvi. p. 786, was discovered in a totally different kind of country from that of the Para kind, and it appears more likely to succeed in India than the latter. Dr. King's object, with both the Ceara and Para rubbers, will be to propagate as large a stock of young plants of each as possible, to find out spots with climates suitable for each, and to have small plantations made wherever efficient supervision can be secured in such places.

Regarding the cultivation of vanilla in India, it seems conclusive that the climate about Calcutta, or even in Southern India, at Bangalore, is unsuited to its culture. At the last-named place it was at one time reported to be thriving, but a similar conclusion to that of Dr King, namely, that it cannot be grown as a successfu crop, has lately been arrived at. Dr. King's concluding words on this subject, that the plants now in the Calcutta garden will, of course, be attended to, but that he does not think it worth while to go to any further expense in attempting to make a plantation of it to be conducted on commercial principles, seems to seal the fate of vanilla culture in India.

On the subject of paper materials, baobab and bamboo take a first place. As is well-known, the first is a native of Africa, but some large trees of it are found in India, near Calcutta, Patna, Agra, as well as in other places. The application of baobab bark for paper-making originated a few years since, when it was brought in some quantities from the Portuguese settlements in Africa. Its value soon became known, and it proved an excellent paper material, the only obstacle to its extensive utilisation being the insufficiency in the supply, for it was apparent that the baobab tree, as found in a wild state, would be totally inadequate to cope with the demand. The idea then arose as to the feasibility of its cultivation in India, and on this point Dr. King says, "I made, three years ago, a small plantation of it with the view of testing the possibility of growing it sufficiently cheaply to be used as a paper-fibre. For the past two years the plants put out here received a rough kind of cultivation, and the grass between them was regularly cut, but, as this could hardly be afforded in a plantation conducted on commercial principles, I did not think it fair to the experiment to continue even the little cultivation which the plants had hitherto received. During the past year the young baobabs have, therefore, had to fight their own battle, and it is quite clear that the majority of them are going to be mastered by the coarse, deep-rooting grasses which infest the soil everywhere in the plains of Bengal. Such plants as enjoy the shade of a large tree in the neighbourhood of the plantation, continue to look fairly healthy, but those that stand in the open look very sickly. If baobab were to be grown to a profit, it would be hardly feasible to give it cultivation, however rough, after the first year, and it might not be always possible to give it shade. Considering, moreover, the comparatively slow growth of the species (a tree of 20 years, grown in the open, girths about 3½ feet at the base, and is about 15 feet high), I am driven to the conclusion that baobab is not likely to afford in India a sufficiently cheap paper fibre. My own impression is that a plant yielding an annual crop is more likely to fulfil the financial conditions of success than any perennial which, like baobab, yields a crop only after many years." As a test of this, Dr. King has sent to the India-office samples of four common Indian plants, namely, the stems and leaves of the bhabar-gheas (*Eriophorum comosum*), of the North-Western Provinces, which is very largely used as a material for ropes in Upper India; stems and leaves of the kash (*Saccharum spontaneum*), a tall coarse grass, too abundant in waste places, over a large area of India; stems and leaves of ooloo (*Imperata cylindrica*), the commonest grass in Lower Bengal; and stems and leaves of the hogla, or giant bulrush (*Typha elephantina*), abundant in marshy places and by the sides of streams all over Lower Bengal. The first, the *Eriophorum*, not growing naturally in Lower Bengal, would reach a seaport charged by a heavy cost for long carriage, and consequently is practically excluded from competition in the export market; the other three, however, being very common plants, and very widely distributed, could be brought to Calcutta in any quantity, and at very low rates. The samples sent by Dr. King were handed to Mr. Thomas Routledge, the paper-maker, of Ford Works, Sunderland, who reports that "all four will unquestionably make paper, the *Eriophorum* being the best and most easily worked, a small quantity of bleach bringing it into good order. The ultimate fibre is very fine and delicate, rather more so than esparto, and about the same strength. The yield (42 per cent.) is somewhat less." Mr. Routledge further thinks that

the *Eriophorum* will make a quality of paper equal to esparto. Regarding the other three plants, Mr. Routledge reports as follows:—"The grass marked *Saccharum spontaneum* ranks next to *Eriophorum* in quality, it is more tender, and certainly not equal to esparto; it yields 44 per cent. of fibre. The grass *Imperata cylindrica* I do not think suitable for paper, certainly not for printing, although it may suit for what are termed small hands and rough packing papers. It is full of small joints and knots (especially the lower portions of the stalk), which result in harsh woody sheaves. It gives a yield of 41 per cent.

"The *Typha latifolia* gives a very strong fibre when purged of the glutinous compounds living in its cellular tissue; but in consequence of this mass of glutin the yield is very small (only 28 per cent.); it is also extremely difficult to bleach, and loses most of its strength when subjected to that process.

"I do not consider that it would pay commercially to attempt to treat any of these fibrous materials for conversion into 'stock' for European use, although very possibly, if procurable in abundance and at cheap rates, they might be employed for paper-making locally with advantage.

"To come into this (the home) market, any material must be superior to esparto in quality, as no matter how cheap the raw material may be in India, the cost and charge for converting it into stock, and transport to Europe, will bring its price, to afford any profit to the producer, as high, or nearly as high, as esparto.

"The importer, therefore, must be prepared to sell his stock as cheap, or nearly as cheap as esparto, reduced to the same condition of stock, and must also give the inducement of superiority of quality."

Regarding the use of young shoots of bamboo for paper stock, a use which Mr. Routledge has strongly advocated in his pamphlet on the subject, as well as in the pages of this *Journal*, Dr. King says he has, during the last two or three years, put Mr. Routledge's proposals about coppicing bamboo to a practical test. The reports on these experiments, during the year 1876-77, were reported in this *Journal* for November 2, 1877, vol. xxv., p. 1027. Dr. King's further report on this important and interesting subject is as follows:—"In the beginning of the rainy reason of last year, the brushwood of thin woody twigs which had been produced by each clump, was cut off, but amongst the twigs there were none of the soft, succulent shoots proceeding from the underground stem which are required for Mr. Routledge's process. The early rain of the present season was particularly favourable to the production of young shoots, and the clumps have just again (10th July, 1878) been cleared of every twig produced by them since the previous cutting. The result is that, just as last year, the most of the growth consists of hard woody twigs which proceed from the bases of the stems cut two years ago. There are only a few of the succulent shoots proceeding from underground, and the total yield of materials succulent enough for Mr. Routledge's process is 120 pounds, or an average of 20 pounds of green material per clump. In a pamphlet published on the subject, Mr. Routledge estimates that the green raw material gives 60 per cent. of good paper stock. I am, therefore in a position to give the yield of paper stock of these six clumps during three years. The yield during the first year was about 17 pounds per clump (equal allowing 80 clumps to the acre) to about 1,360 pounds per acre. During the second year the yield was nothing, and during the third year it was three pounds per clump, or equal to 240 pounds per acre. Mr. Routledge estimates that (according to a method of planting which he proposes, but which I believe to be quite impracticable) the yield per acre would be six tons, and that this yield would be annual. The value of the paper-stock delivered in England would be from £20 to £25 per ton, so that, even assuming (which is by no means the case) that green bamboos are of very little value, the proposed new industry does not present a hopeful financial aspect." Thus it will be seen that the question of the profitable production of bamboo shoots for paper-making seems far from being settled.

Amongst economic trees introduced into India through the Calcutta Botanic Garden may be mentioned the carob (*Ceratonia siliqua*) and the *Pithecolobium* or *Calliandra saman*, which has recently been identified as the "rain-tree," about which so much interest was excited some months since, owing to its being stated that the leaves exuded a copious supply of moisture, the cause of which has been described in *Nature* as the work of multitudes of "Cicadas sucking the juices of the tender young branches and leaves, and squirting forth slender streams of limpid fluid." The tree forms a dense spreading head, and is a rapid grower. Dr. King reports that the gardens possess two sets of this tree, one consisting of five trees about 11 years old, and the other of 84 trees, which were planted in an avenue four years ago. The tree, though a native of Peru, appears perfectly at home in the climate and soil of Bengal. The habit of the tree in forming a thick trunk, and branching at a comparatively short distance from the ground, together with its naturally soft wood, makes it useless as a timber tree, except perhaps for firewood. As a shade tree, however, Dr. King considers it unequalled by any in Bengal. He says:—"It grows faster than any indigenous tree known to me, and the only introduced tree which rivals it is the *Casuarina equisetifolia*. The five older trees in this garden girth on an average seven feet nine inches at three feet from the ground; while of the four-year old trees, which are planted 32 feet apart, as an avenue on either side of a road 20 feet wide, the heads now meet across the road and afford an excellent shade. The average heights of these younger trees is about 20 feet, and the average girth of their stems at three feet from the ground is 29 inches. The older trees have this year, for the first time, given seed; the pod is quite as sweet as that of the carob, and is abundantly produced, and altogether I consider *Pithecolobium saman* a much more hopeful source of cattle fodder than the carob, while as a rapid grower it is unrivalled." Regarding the prospect of the carob in India, it is not considered at all likely to succeed, the young plants, in fact, damping off before they were large enough to be planted out.

During the year experiments were made in raising several species of *Eucalyptus*, seeds of which had been sent by the Indian Government for trial; none of these experiments were satisfactory, the seeds either did not germinate, or died off during the rainy season. This, Dr. King says, is quite in accordance with former experience, which goes to show that the project of ameliorating the malarious climate of Lower Bengal by the free planting of *Eucalyptus* is perfectly Utopian. The water-logged alluvial soil, and hot steamy climate of this part of India, are totally unsuited to any species of these Australian trees which has yet been tried.

CORRESPONDENCE.

RAILWAYS TO INDIA AND TURKEY.

To what I said last night at the discussion on Mr. Hyde Clarke's paper, I should like to add what I should have said had the time not been so late when I spoke.

I should not myself locate the India railway from

Baghdad to Kurachee so far south as shown on the map, as I understand the country south of Shiraz and through Beloochistan is all nomad, or unsettled.

We find that the nomads, who are quite irresponsible parties, amuse themselves by removing the fish plates when they find a loose bolt, and their flocks and cattle stray on the line and interfere with the traffic. The resident population, on the contrary, protect the railway by every means in their power. Those especially who have been employed on the works feel that they have a part ownership in the railway.

Moreover, I count on an average dividend from local traffic of from 2 to 3 per cent. on the cost of construction.

On the line I advocate—through Mosul, Kizcalay Kúm, Meschid, Heraat, and Candahar—the population is in most parts settled, and the traffic will be larger than on any other line through Persia. Strategically, this line is indefensible, and so is every other line through Persia and Afganistan, but that which I propose will form a moral barrier to the encroachments of Russia, which, when constructed will (except on special occasions) dispense with the services of the military engineer, by immediately producing a state of civilisation sufficient for the purposes of traffic.

The contract price for works would not in my opinion exceed on the average £9,500 per mile. There is, I think, some misconception of my meaning in your notice of my remarks on the labour question. What I said, or what I intended to say, yesterday was, that 400 excavators, and 100 platelayers and masons, &c., would, in most parts of that country, construct fifty miles of line in one year; twelve such gangs would complete a line to India in five years. In the course of the line many times six thousand idlers would be found, glad to work, whose employment would benefit the country, and not reduce the present amount of agricultural labour.

C. E. Austin.

1, Westminster Chambers, Victoria-street, S.W.
12th December, 1848.

SEWAGE FARMS IN HORTICULTURAL COMPETITION.

The appearance of sewer farm produce in horticultural competitions, as stated in the subjoined account, is highly satisfactory, and it is to be hoped that such competitions will be advanced systematically in the interest of sanitary as well as of horticultural science. It is to be observed, that plant feeding with liquified manure is the art of the horticulturist—that is to say, for the attainment of the best results ultimately attainable—and is wholly distinct from plant feeding with solid manures, the work of the common farmer. Already, whilst the yield of the solid manure farming on a given area is as one, and whilst the yield of the highest of the solid manure farming is about three and a half, the yield from liquified manure farming, under rudimentary conditions, is as five. The increased bulk obtained by liquified manure farming is, moreover, accompanied by an improved quality of the produce. And this is done by direct applications from the sewer to the land, without any intermediate treatment, chemical or other, save the screening of the more solid matter known as sludge. But this sludge, which is held forth by theorists and speculators as a work of foremost difficulty, is treated by practicians as of no serious amount or difficulty whatever. At Bedford, when I visited it, I was informed that it was worked in as solid manure as in the market garden farms, and occupied only two and a-half per cent. of the space of the market sewage farm. Much the same results were shown in other places. With the sewage of the largest towns, or of the metropolis, the small proportion of the sludge may probably be of a quantity to be a subject of profitable exploitation. It is to be noted, moreover, that the present successes of sewage farms are generally obtained, under more or less difficulty, by the sewage farmer, by the depreciation of the quality of the sewage, by bad engineering work, by the fæcal matter in sewers of deposit, or in house drains, in conditions of stagnant deposit and putrid decomposition, to the injury of the public health and the loss of the farmer; also by excessive dilution by the waste of water beyond the actual consumption, a waste in many places of more than one half the water distributed, arising from bad supervising and defective service pipes, and also at times from the blunder of admitting the rainfall into the sewers and sending that to the land where it is detrimental, instead of into the rivers. In the face of the great yields obtained, nevertheless, it is demanded of the sewage farmer whether sewage pays? This question of the profit made is a question of delicacy, which a common farmer does not feel himself bound to answer; a question which no land valuer puts to a tenant farmer if he expects the truth in answer, and the surveyor must fudge for himself by an estimate of the yield and of the cost of production. Light is, however, got on the subject occasionally by the letting of the cuttings, and at Edinburgh they fetch £30 per acre. At other places £20 and £25 per acre. Under all difficulties and observations the sewage farms are extending, and at the Congress at Stafford, Mr. Birch, the engineer, gave an enumeration of a hundred of them, large and small. They are extending in France and Belguim, and a letter from Mr. Aird to Mr. Mechi, which I append, gives an account of the progress made with them in Germany, which is in accordance with my own information. These horticultural competitions are of the first importance, as tending to advance science and in the improvement of the special culture, so important as a means of sanitation as well as of improved production.

It has been suggested that sewage culture should be tried on hops. The effect of sewage culture is to augment the essential oils and the aroma of plants. The finest perfumes of Paris are now obtained by it, as well as an augmentation of saccharine and farinaceous material. Rice culture has been recommended for trial. Sewage may be well tried on many plants, and on fruit trees. It would be useful to give prizes for the best examples of exotic plants, for which sewage proved to be suitable. I venture to suggest that the managers of public sewage farms would render a service if they would bestow a strip of their farms to experimental growths out of the range of ordinary agriculture.

E. Chadwick.

In an account of the Berkshire root show, given in the *Local Government Chronicle*, it is stated that "the chief feature and central point of interest of the show was the section of prizes for roots grown with sewage. The display was wonderful in itself, and, as showing what may be accomplished by the judicious use of sewage, should be taken note of by the advocates of sewage utilisation. There were five classes, and in all five the first prize was awarded to the Reading Urban Sanitary Authority. This might be supposed to indicate that the competition was weak; but it was really the opposite. The completeness of the victory was due to the exceptional character of the exhibits. In the class of Sutton's Mammoth Long Red Mangolds, the crop was 110 tons to the acre; the golden tankard mangolds, 88 tons to the acre; yellow intermediate mangolds, 77 tons; and yellow globes 77 tons per acre. These are crops which have never, we believe, been equalled. This is the first year of the sewage operations at Reading, and the ground is new and fresh, and some

seem to fear that with such heavy manuring it may get sewage-clogged. But the taking back from the soil such enormous crops will go far to prevent that; and Mr. Champion has shown himself too able and watchful a manager not to have his eye on any such tendency. Single roots in the prize exhibits already referred to surpass any of those from the Reading Farm; but the latter were large, clean, well-shaped, and even, and in all respects thoroughly creditable specimens. Exceptionally large roots are obtained in fancy farms by wide sowing, ample manuring, and careful culture; but for such heavy crops as are obtained on the sewage farms there must be comparatively close sowing, and the weight is the result of evenness of crop throughout. It is still constantly and confidently asserted that no sewage farm returns a profit when all expenses are taken into account; but certainly, with such crops as these, the Reading Sewage Farm ought to show a favourable balance-sheet. As an illustration of the value of the sewage treatment, we may mention that we were informed that, on about fifty acres of the farm to which sewage was not applied, but where the seed was the same and the culture similar, the crops yielded under half the weight of the sewage-treated portion. The Reading Sewage Farm was the most successful, but by no means the only one that showed good results, The Eton Sewage Farm gained the second prize in four classes, and had very heavy and good specimens of long reds, yellow globes, golden tankards, and yellow intermediate mangolds. The Birmingham Sewage Farm had a very good display of clean and shapely roots, though lighter than those of some of the other competitors. The Bedford Sewage Farm, Mr. Bailey Denton's, at Abingdon, the Earl of Warwick's, those of the London Central, and the South Metropolitan District Schools contributed exhibits which two or three years ago would have indubitably carried off the honours, but were now distanced in the supreme article of weight. The Bedford Farm came second to Reading in the class of green kohl rabi, and so near that it required a keen eye to place them. We should have been glad to be told the weight of the crops per acre on some of these farms, and, in the older of them, whether there has been any deterioration from continued sewaging and root cropping."

The following letter is from Mr. Alex. Aird, of Danzig, to Mr. J. J. Mechi:—

"I was indeed glad to read your last letter to the *Times*, knowing so well, from my own experience, that your repeated appeals for the prevention of the present enormous waste of manure must in time be fully recognised and appreciated. Here, with our Danzig Sewage Farm, we are in our seventh year, and with, I am happy to say, in every respects most happy results. As you will remember, the land we own is, or was, of the poorest possible kind—pure 'dunen' sand—and our crops this year, chiefly wheat, barley and rye, have exceeded, both in quantity and quality (as attested by the market agents) those grown on the richest land in the province.

"During the past year our farm has been visited by individuals and deputations from all parts of Germany, Russia, &c., and in every case our visitors have expressed their opinion that the system and detail arrangements are "convincing." I regret to add that not one Englishman has paid us a visit. I fear the reason is the general opinion that Danzig is a very disagreeable town on the Russian frontier, whereas Danzig can only be described as 'Nuremburg-on-the-Sea,' surrounded by the most charming hills and wood scenery.

"That our arrangements here have proved successful, you, as a practical man, will understand from the fact of our having closed a similar contract with the municipal authorities of Breslau (270,000 inhabitants), we undertaking the laying out of the irrigation lands (3,000 acres) and taking the same in lease for a term of 12 years, on terms satisfactory both for the town and ourselves.

"In Berlin the sewage irrigation system has already proved a very grand success, and deservedly so. All vegetables are sold at a much cheaper rate than formerly, and arrangements have been made in the interests of public health to supply the poorer families with pure milk at a nominal rate. I can safely say that all the larger towns in Germany are preparing to carry out the same system, the German Government having wisely determined to prevent in good time the pollution of their rivers.

"I read all the English publications I can obtain on this subject, and am almost regretting the 'bungling' (I fear this is the only word to use) that takes place. Most of all do I regret, and this I consider really a disgrace to England, that the Metropolitan Board of Works has so entirely 'shifted the question.' A very moderate outlay would have sufficed to prove results which would have long since established the truth you and I already recognise as to the national benefits to be derived from 'utilisation of sewage.'"

GENERAL NOTES.

Products of Combustion in the Electric Arc.—Mr. T. Wills, F.C.S., has been making some experiments on the production of oxides of nitrogen in the electric arc. The atmosphere of course consists mainly of oxygen and nitrogen, but simply in a state of mechanical mixture; if these gases become chemically combined, they form several oxides of nitrogen, most of which are strong and corrosive acids. At a high temperature small quantities of these gases can be made to unite. This is the case when electric sparks are passed through air; also during the combustion in air of a very hot flame, such as that of hydrogen; it therefore seemed probable that, as the temperature of the electric arc is undoubtedly very high, nitric acid, or some other oxide of nitrogen, might be produced by the electric light. The first experiment was rather surprising. A glass cylinder placed over an electric lamp (Foucault's regulator) for two minutes, and afterwards examined, was seen to contain a perceptible amount of red fumes, due to peroxide of nitrogen (N_2O_4). The air surrounding the lamp was next drawn through a solution of potash, and the amount of nitric acid estimated; this gave 10 to 12 grains of nitric acid produced per hour (it may eventually prove to be more, the difficulty being to collect the whole of it). The next step in the research will be to examine the various forms of electric light, with a view to determine the amount of nitric acid produced by each. The subject was to form the basis of a communication to the Chemical Society last night.

NOTICES.

MEETINGS FOR THE ENSUING WEEK.

Mon.... London Institution, Finsbury-circus, E.C., 5 p.m. Mr. W. R. S. Ralston, "A Story-telling."

Tues. ...Metropolitan Scientific Association, 160a, Aldersgate-street, E.C., 7 p.m.

Fri.......Quekett Microscopical Club, University College, W.C., 8 p.m.

Sat......Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lectures.) Prof. Dewar, "A Soap Bubble." (Lecture I.)

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

DEATH OF H.R.H. THE PRINCESS ALICE.

At their meeting on Monday last, the 23rd instant, the Council passed the following resolution :—

"The Council of the Society of Arts desire to convey to His Royal Highness the Prince of Wales, the President of the Society, the expression of their heartfelt sympathy and condolence on the occasion of the sad loss His Royal Highness has sustained by the death of his beloved sister, Her Royal Highness the Princess Alice of Great Britain, Grand Duchess of Hesse Darmstadt, whose bright example, as a daughter, sister, wife, and mother, will ever remain in the memories of all who live to labour for the happiness and improvement of mankind."

The Secretary was desired to communicate the same to His Royal Highness.

JUVENILE LECTURES.

The usual short course of lectures adapted for a juvenile audience will be given by Mr. W. R. S. Ralston, M.A., on "The Mythology of Fairy Tales." The dates for the lectures will be Friday, the 3rd, and Friday, the 10th of January next. The lectures will commence at seven o'clock. As the number of seats is limited, admission will be by ticket only, and when sufficient tickets have been issued to fill the Room, the issue will be discontinued. The tickets will be supplied strictly in the order in which the applications are received. Subject to these conditions, each member is entitled to a ticket admitting two children and one adult. The tickets are now in course of issue, and members requiring them are requested to make application to the Secretary at once. The tickets are now nearly all disposed of, so that only a few more applications can be entertained.

CANTOR LECTURES.

MATHEMATICAL INSTRUMENTS.

By W. Mattieu Williams.

Lecture I.—Delivered Monday, November 25th, 1878.

Before I enter upon details, it is necessary to define the nature and limits of my subject, especially as the name "Mathematical Instruments" commonly suggests nothing beyond those little cases of drawing instruments which contain compasses, scales, protractor, &c.

In order to indicate how many instruments are properly described as mathematical, we must first define the functions and limits of mathematics itself.

"Mathematics in general is the science of quantity; or the science which investigates the means of measuring quantity." This is the definition of Euler. Mathematics being the science which investigates the means of measuring quantities, the practical measuring of quantities may fairly be called mathematical art, the implements or materials for which are mathematical instruments.

It is well to understand at the outset the distinction between instruments for observation, or the implements of discovery; and instruments for measuring, or mathematical instruments properly so-called.

I have here two pieces of gold leaf suitably mounted. I now rub this piece of sealing wax on my sleeve, and bring it near to this brass plate with which the gold leaves are connected. They fly apart, indicating the action of some amount of electrical force, but they do not measure that amount. Therefore, this is not a mathematical instrument—it is not an electrometer, though often so-called. The Greek root *metron*, a measure, is there misapplied, and the proper name for this instrument is an electroscope, from *elektron* and *skopeo*, "I see," as it shows or enables us to see that electrical force is exerted. The instrument of Coulomb is both an electroscope and electrometer, as it shows the presence of electrical force by the repulsion of the pith ball, and measures the force of that repulsion by the torsion of the wire by which the ball is suspended. The electroscope is an instrument which enables me to see, observe, or discover something otherwise invisible; the electrometer to measure a quantity otherwise unknown; the latter is the mathematical instrument.

Again, with this instrument I am able to see little objects otherwise invisible, therefore it is called a microscope, from *micros*, little, and *scopeo*, "I see." When I add to it this slip of glass, upon which are engraved cross lines $\frac{1}{5000}$ of an inch apart, I not only see the little object, but may measure it by counting the number of squares it covers. The strip of glass is called a micrometer, and is a mathematical instrument.

Here I have another optical instrument. By look-

ing through the tube, I may see objects too distant to be otherwise visible, or may more fully define visible distant objects. This is therefore called a telescope, from *tele*, far, and *skopeo*. When simply used for this purpose, it is not a mathematical instrument, although mathematical principles may be involved in its construction. Here, however, I have added to it, in the focus of the eye-piece, two parallel wires, which may be brought close together, or separated gradually, by turning this projecting collar, which has three sets of divisions engraved upon it, one set marked "infantry," another "cavalry," and the third "camels." Its use is to measure distances for artillery or rifle firing. Either of these objects becomes visually smaller in proportion to its distance from the eye. In using it, the divided collar is turned until the object is just measured from head to foot by the distance between the wires. Then, by reference to the divisions, its distance in yards is given, according to whether it is a camel, a man on horseback, or a man of soldierly stature standing on foot. It may, of course, be applied to other objects of corresponding heights. This telescope thus enables us not only to see the distant object, but also to measure its distance within certain limits of error. It is therefore, by this device, converted into a mathematical instrument.

If I add to a solution of Epsom salts a solution of chloride of barium, a dense precipitate is thrown down, and thus I am able (with proper precautions) to predicate the existence of sulphuric acid, and by the chemical balance, a purely mathematical instrument, I am able to "quantify the predicate," and this quantification by a mathematical instrument of the predicates supplied by observation, experiment, and induction, is the business of mathematics. Thus, a yard measure, a quart pot, a pair of scales, are mathematical instruments; and when the milk-boy measures a halfpenny worth of milk, he performs an operation as truly mathematical as that which recently exercised the co-operation and highest skill of the greatest mathematicians of Europe and America, when they combined to measure the solar parallax, and therefrom the distance between our world and the sun.

I press this upon your attention, because a notion commonly prevails that mathematics and mathematical operations are so abstruse, and profound, and difficult, that they are beyond the reach of such people as artisans and others engaged in earning their daily bread by ordinary work. This is a very mischievous delusion. There is no study so completely within the reach of everybody as mathematics. It demands for its demonstrations less apparatus than any other branch of physical science, and fewer books. The genius demanded is simply the faculty of close attention and steady plodding perseverance. The highest pinnacles of mathematical science are reached by walking up gradual slopes, not by dashing or brilliant flights.

I have in my pocket a mathematical instrument of almost unlimited utility. It properly belongs to my last lecture, as it falls among the instruments for recording or representing the results of mathematical processes. Here it is. A piece of slate pencil, a mathematical instrument for the million. If the million would but use it diligently and well, our union workhouses might all be converted into technological colleges, and we should have very little to fear from foreign competition.

I shall presently show you other instruments, by the aid of which some of the most profound practical operations of the higher mathematics are performed, and though I can no more teach you how to perform these operations than I can show you all that may be done with a slate pencil, it is probable that the nature of some of these operations may be rendered clear enough to satisfy you that they involve a kind of mental discipline, which we all need.

The function of all these instruments, as we shall see, and the aim of all the higher operations of mathematics, is to obtain the utmost possible quantitative accuracy. This sort of systematic accuracy is the chief characteristic of scientific knowledge, as distinguished from ordinary vulgar, unsystematic, slip-shod knowledge. The farmer, the cook, artisans of all trades, are operating by means of the forces of nature which science investigates, and they can only do their work well and economically by working on sound scientific principles, the very essence of such principles being their mathematical or quantitative accuracy.

Half the blunders of our daily life arise from looseness of thought, due to a want of quantitative intellectual accuracy, and nearly all our miseries from looseness of action, arising from want of moral accuracy.

The intellectual conscientiousness which is so imperatively demanded in all mathematical operations cannot be habitually practised without promoting moral conscientiousness. I am not prepared to affirm that mathematicians are all pure and blameless, or that mathematical instrument makers are all models of moral excellence. I know they were not so 40 years ago, when I was an apprentice and among them, but I believe they have much improved since. The chief reason why the moral influence of mathematical precision is so little felt, is that we still fail to introduce it into the affairs of daily life. Just as a man may save up all his religion for Sunday and leave it behind on Monday, so may scientific conscientiousness be left behind in the observatory or laboratory, and that respect for the perpendicular, which every good mathematical instrument maker maintains in the workshop, may forsake him on Saturday night after visiting the public house.

Quantitativity, or variability of amount, is an attribute of everything that we are able to investigate and comprehend. We may thus consider the quantity of one thing, and of another thing, and another and another, and so on of all things within the range of our knowledge. But we can also regard quantity in another manner. We may consider the quantity of anything without considering what the thing may be, and thus come to conclusions which apply to the quantities of everything.

These last are called abstract quantities, because, in considering them, we deal with the idea of quantity itself, abstracted or drawn away from any particular individual or collective objects. Thus, when we speak of "five" we mean five anythings, five fingers, five pounds, five yards, five camels, and all we say of such five applies to five everythings. Twice five is ten, ten anythings, and

ten everythings. The mathematical instruments for expressing such abstract quantities I need not tell you are figures; nor need I dwell on their origin beyond reminding you that the primitive instruments of abstract mathematics were the fingers of the human hand; hence the universality of decimal notation, or counting up to ten, and then starting afresh, and then counting how many tens, and how many ten tens, and so on.

It is worth our while to pause for a moment here, and reflect on the vast power we gain by this abstraction. When we say twice five are ten, or two and two are four, we take a mental grasp of the whole universe, so far as the quantities are concerned. A hen may have an idea of two eggs and two more, and possibly of four or five eggs; may count them, and miss one or two if taken away. A dog may have an idea of four or five bones. These animals may regard eggs and bones, not merely as eggs and bones, but, further, as quantities of eggs or bones, and act upon such ideas; but the power of considering quantities in the abstract, of operating upon, adding and subtracting abstract quantities, and obtaining abstract and universal results applicable to the quantities of anything and everything, is an attribute of the human intellect unshared and unapproached by any of our four-legged, four-handed, or otherwise-extremitied fellow creatures.

The skilled mathematician carries abstraction still further, and operates upon abstract representatives of abstract quantities; he abstracts the very figures themselves, and performs operations that apply not merely to 1, 2, 3, 4, or 5, and so on, but also to even possible quantity. He does this by operating upon letters, such as *a*, *b*, *c*, &c., which may mean any or every known quantity of any or everything; and he goes further still, by using *x*, *y*, and *z*, as abstract representatives of unknown quantities, and thus operates upon quantities before knowing what they are. When this device is not abused, it confers great additional power, as all know who have only gone as far as simple equations. By thus extending the process of abstraction, the algebraist has an advantage over the mere arithmetician analogous to that which the arithmetician has over the mere counter of tangible objects.

To proceed any further with the description of these and other devices, and the uses to which they are applied, would be to lecture on abstract mathematics, which would be out of place here even if I were qualified to do it. My subject essentially runs in the concrete direction, and deals with the devices for practically conducting definite kinds of measurement.

As every physical object with which we are acquainted, or of which we can form any rational idea, has magnitude as its primary and essential necessary property, the measurement of magnitude stands first to be considered.

The true magnitude of an object is the amount of space it occupies; the visual magnitude, or magnitude as usually understood, is the magnitude of the space included within its boundaries. Thus, in ordinary description, the size of this bottle, or this sponge, or this piece of pumice, is determined by measuring to its outsides; that is, including all the space within its boundaries; but its absolute magnitude is much less, for it does not fill all the space thus measured, being hollow or porous. As substances apparently continuous may have invisible pores, it is usual to accept the ordinary or visible magnitude as that to be measured. The determination of absolute or actual magnitude is probably impossible.

We may go a little way into the philosophy of this, taking care not to plunge too deeply, lest we alight in obscurity. It will be well to understand that magnitude is an idea, and in measuring the size of a body, we are measuring this idea. An idea may be simple or complex, continuous or discrete. Thus our idea of a line is simple and continuous, but our idea of a chain is complex or discrete. It is made up of a number of links, or elementary parts. Now, if our idea of magnitude had any elementary parts, if it were discrete or broken up, like our idea of sandstone or granite, and if these elementary parts were all alike, we could measure magnitude by reference to these primary atoms or elements of magnitude. These would become our natural units of measurement, and we could describe magnitudes by stating the number of such units they contain.

Failing this natural standard, we are compelled to adopt an artificial one, which I shall describe presently; and our mode of measurement consists primarily in applying this standard to the object to be measured, and determining how many parts or repetitions of the standard are included in its whole magnitude. Any enclosed space has three dimensions, length, breadth, and thickness, but the instrument for measuring all these requires but one dimension, viz., length. Although we cannot construct any measure which physically fulfils the mathematician's definition of a line, viz., that which has length without breath or thickness, yet in using our measure we regard it as such a line only. But the repetition or sub-division of a given line can only measure its own attribute, viz., length, therefore some device is necessary to measure that combination of length and breadth which forms a surface. An additional unit is required for the expression of superficial magnitude, though its actual measurement be effected by the application of the linear measure. This, as you all know, is a supposed or ideal surface of equal length and breadth, with all its sides at right angles to each other; a square inch, square foot, or square yard, &c. In like manner we measure all the three dimensions of a body or entire space enclosed, by making repetitions of a standard cube. Thus the term cubic contents may be applied to a body by no means cubical.

The common definition of a point, viz., "that which has neither length, breadth, nor thickness," is no definition at all, it is merely a scholastic outbreak of pedantic paradox, a string of negations the sum total of which is nothing. Nothing demands no measurement, and cannot be measured, but a point properly defined and understood, expresses a positive idea, which demands and has received very elaborate measurement. The mathematician uses the word "point" to express the simple idea of position, unmixed with any other idea of dimensions. Now, mere position, although not measurable in terms of length, breadth, and thickness, is determinable by means of measurement.

In measuring magnitude we measure the space in-

cluded within or bounded by the body. In determining position, we measure some portion of the space without, outside, or around the point. The instruments used for such measurement will demand a whole lecture for themselves. The measurement or determination of position, like that of dimensions, is the measurement of space or matter regarded as inactive. But science deals with the activities of matter, that is, with its changes of position, or movements, and the causes of these movements, or variations of motion. It demands the measurement of these causes, whether visible or invisible. There are many varieties of these, but under the one general name of "force" we include all that can originate or modify any kind of motion. We cannot see a force itself, we can only see its results, or the disturbances it produces. How, then, can we measure it? Evidently by the magnitude of those disturbances. I will not at present touch upon the measurement of the forces of light, heat, electricity, &c., but take that of gravitation as typical.

A little philosophy will help us here again. We know nothing of the external world but by virtue of its action upon ourselves, and that action is limited by our capacity to respond, or to be acted upon by it. Our sensations are all internal, but we refer them outwards, and, when an object excites within us the sensation of redness, darkness, or brightness, we call the external object red, or dark, or bright, &c. Now, this idea of force is similarly derived. We know by internal experience, based on muscular sensation, that we cannot set a mass of matter in motion, or stop or deflect its motion, without the exertion of muscular effort; and hence we naturally and irresistibly infer that, to produce the like effect, a similar effort must be exerted upon it. This effort we call mechanical force, or the force which originates, arrests, or modifies the motion of visible masses of matter. Thus, when we see this piece of iron lifted by this magnet, we naturally infer that the magnet does this by the same means as we should do it ourselves—that is, by the exertion of a pulling force—and we take a couple of Latin roots, stick them together, and build up the word "attraction," which means "pulling towards." Then we say the magnet attracts, or exerts a force of attraction upon the iron. We see an apple fall, and we say that the earth attracts the apple.

It is well to understand clearly that this attraction idea is a pure hypothesis. We see the motion, and feel the force. To explain these sensations, we suppose the exertion of attraction, or pulling.

When internal changes—which we attribute to molecular, or invisible internal movements—are produced, we, in strict analogy, attribute these to the operation of molecular force, or forces.

Our chief experience of muscular effort is that which is directed to the support of our own bodies and the raising, or supporting, of other bodies, *i.e.*, the effort we use to overcome or counteract their gravitation. The force of gravitation is thus the most fully appreciated, the most typical and familiar of all external forces, and serves as the best basis for the measurement of force, and the expression of our ideas and estimates of force.

A pound weight is simply a gravitation measure, and when we say that steam at a certain temperature will exert a pressure of so many pounds to the square inch, or balance a column of mercury of a certain height, we measure its expansive energy by a gravitation standard.

In measuring the expenditure of mechanical energy, or exertion of mechanical force, that is, of work actually done by it, we still use a gravitation standard, the "foot pound," or the work done in raising one pound to the height of one foot. If "horse-power" literally meant the power of a horse, it would be a very indefinite unit, and we should have to ask, which horse? as the actual power of horses is so variable. But the "horse-power" of the modern engineer is a definite gravitation standard, *i.e.*, a power sufficient to raise 33,000 lbs. to the height of one foot in one minute.

I have already shown that the measurement of the dimensions of a body does not measure its quantity of matter. This is measured by gravitation, or by weighing it, and the quantity thus ascertained is called its mass. It should, however, be understood that this determination of mass or quantity of matter by weighing involves a theoretical assumption, viz., that the gravitating energy of a body is always proportionate to the quantity of matter it contains. It might be otherwise. Gravitating energy might, like chemical or calorific energy, vary with the composition as well as with the quantity of matter. Thus a pound of water, at a given temperature exerts far more calorific energy than a pound of iron or mercury. In cooling down one degree the one pound of water gives out as much heat as does 30 lbs. of mercury in cooling to the same extent; in like matter a given weight of water requires 30 times as much heat to raise its temperature equally with an equal weight of mercury. The chemical energy of one ounce of hydrogen is equal to that of 207 ozs. of lead, 197 ozs. of gold, 56 ozs. of iron, and so on.

Our justification for the assumption that gravitation does measure the actual quantity of matter, is that the amount of gravitating force exerted by any given sample of matter is absolutely unalterable, whatever other changes may occur. We may alter its dimensions, its colour, its hardness, its temperature, its chemical energies, its solidity or fluidity, and its other attributes; but all the Queen's horses and all the Queen's men, including all the Fellows of the Royal Society, cannot increase or diminish its gravitating energy by one-thousandth part of a grain. They may beat it, cut it, pulverise it, dissolve it, evaporate it, electrify it, magnetise it, bury it, burn it, or otherwise torture it, but its definite measureable amount of gravitating power or mass remains unaltered, and, as far as we know, unalterable. Hence we may safely affirm that this, under all circumstances, represents its actual quantity.

The absolute constancy of the weight of every form of matter renders the balance the tribunal of final appeal before which all questions concerning its composition is tried.

Time will not permit me to explain how the "imponderables," as they were formerly named, viz., heat, light, electricity, magnetism, and chemical affinity, may be converted into mechanical force, and that force finally measured by the standard of gravitation. In many cases the measurement of these forces is effected by the comparative measurement of our sensations. In

photometry, for instance, we compare the sensible effect of standard candles with that source of light to be measured.

We have, at present, no mathematical instrument for measuring the relative saporific energies of beef, mutton, pork, &c. Tea tasters and wine tasters measure flavour empirically; the sweetening powers of different sugars have been numerically determined. A "council of noses" is sometimes held in a laboratory, but this is for qualitative, not quantitative, determination of the probable origin of certain odours.

Count Rumford, when engaged in feeding the rogues and vagabonds of Munich, and fattening them at a cost of a halfpenny per day, had to economise flavours considerably, and attempted a quantitative determination of the flavouring energies of various viands, by diffusing them through his workhouse soup, and ascertaining how far they could be outspread and still remain appreciable.

Before concluding these introductory generalities, and proceeding to the details which will form the subjects of the following lectures, I must not omit one most important class of measurements that is demanded in connection with all other measurements, and which are so commonly disregarded in the common affairs of daily life, although absolutely essential to accuracy in anything. I mean the measurement of error, or liability to error.

A clear perception of the fallibility of our own senses, of the deficiencies in our own knowledge, and the liabilities to blundering in the course of our reasoning processes, is demanded at the very outset of all truly scientific investigations. To these defects in our primary mathematical instrument, the human mind, we have to add those of the secondary or physical instruments, by means of which the mind is applied to the objects of investigation.

Taking the latter class of errors first, I will select a very simple case for illustration. The chemist weighs a precipitate, such as sulphate of baryta, on a balance of the greatest attainable delicacy. It is enclosed in a glass case, to eliminate the errors due to currents of air, and other minute precautions are taken for accuracy sake. Still it requires a force equal to, say, $\frac{1}{1000}$ of a grain to overcome the viscosity of the enclosed air, the friction of the knife edge upon its agate bearings, and to set the beam in motion; or to speak better and simpler English, to turn the scale. It is, therefore, clear that the chemist who uses this is liable to an error which may amount to $\frac{1}{1000}$ of a grain; his precipitate may actually weigh so much more or so much less than his statement of its weight. There are other sources of error to be added to this. When, however, the errors are just as likely to fall on one side of the truth as the other, they may be probably eliminated by several repetitions of the operations, and taking the mean result of all. This narrows the limit of error very materially, and there is a special department of mathematics which measures the degree of such narrowing.

Another simple case. Suppose I wish to measure the altitude of a star—the pole star for example, the altitude of which nearly corresponds to the latitude of the place of observation—by means of this theodolite. Having by the devices presently to be described, set the telescope level, and this semicircle at the same time to read zero, I now elevate the telescope until it catches the star in its optical centre; then read off the angular elevation of the telescope by means of the graduation of the semicircle. But such a semicircle or limb as this will only read to about 20 or 30 seconds. Therefore, in making this observation, there is a liability to instrumental error reaching to *plus* or *minus* 20 or 30 seconds. Besides this, there is a certain liability to error in the starting point, or the levelling of the telescope, and a further outside optical source of error in the refraction of the atmosphere which raises the apparent position of the star.

I might go on multiplying instances selected from the whole circle of the sciences if time permitted. In the highest and most refined process of scientific investigation, the limits of error are carefully studied, and, when they can be defined, the quantitative conclusions are stated accordingly as a certain quantity, *plus* or *minus* the possible error.

As already stated, the primary mathematical instrument, the human mind itself, or its organic apparatus, is liable to errors that in many cases are measurable.

Thus, in certain astronomical observations, the observer has to note the moment at which a star appears to touch a wire or wires stretched across the field of a telescope. The ordinary or, I may now say, the old way of doing this, is to look at the clock as the star approaches the wire, then count the beats of the clock, and then note at which beat, or fraction of the beat, the transit of the wire occurred. This appears simple enough, but, simple as it is, there is no human being whose eye, ear, and internal nervous apparatus of perception and volition are sufficiently perfect to do it accurately. All are subject to error. We neither see, nor hear, nor feel instantaneously. The sensation has to be transmitted from the external organ of senso to the nervous centre, and the mandate suggested by that sensation has to be transmitted outwords. These operations demand time. If we were to agree that you should all stretch forth the right hand, and then all raise it immediately I say "up," and all were to try your utmost, you could not do it simultaneously. Some hands would rise before others, though every one might suppose that he raised his hand at the moment of command.

So, iu the transit observations, all observers err; and they err variously. The most curious feature of this variation of error is that it depends upon personal variations of constitution. Thus, in the same observatory, there may be three assistants, Brown, Jones, and Robinson, and they are tested by making a number of corresponding observations. In every case, Brown is a quarter of a second ahead of Jones, and Jones is half a second ahead of Robinson. This happens again and again; so persistently, that Robinson can no more be blamed for being half a second behind Jones, in time, than for being three inches shorter in height.

What is to be done? If all erred alike—if all observers required just half a second to collect their sensations of sight and hearing, and bring them to bear upon the same perception—then, by setting the clock half a second a-head of the true

time, the recorded time of observation would be corrected. But, failing this, some personal standard of comparison must be taken, and the observers rated to this standard, like chronometers. This is done in observatories, and the result is called the "personal equation" of the individual observer; and this equation is recorded against him, and his observations are all corrected accordingly.

Thus, between 1838 and 1841, a series of transit observations were made at Greenwich and Brussels, by Mr. Sheepshanks and M. Quetelet, in order to determine the longitude of the Brussels Observatory, that of Greenwich being called zero. Before commencing, the two astronomers had to equate themselves and their assistants. Mr. Sheepshanks found himself $\frac{45}{100}$ of a second behind M. Quetelet, $\frac{27}{100}$ before Mr. Main, $\frac{35}{100}$ before Mr. Henry, and $\frac{24}{100}$ before Mr. Ellis. Thus, between Quetelet and Henry, there was a difference of $\frac{80}{100}$ of a second, and if the Greenwich observations had been made by Mr. Henry, and those of Brussels by M. Quetelet, without allowance for personal equation, that large amount of error would have been made, and all due to the different working of the primary human mathematical instruments.

Not only has the personal equation of each observer to be determined on his entrance upon his duties, but it demands periodical revision, as it varies with age and other constitutional affections.

The range of personal equations in this class of observations has been greatly diminished of late by using electrical recorders, of which I shall have to speak hereafter.

MISCELLANEOUS.

FRENCH INDUSTRY AND COMMERCE.—THE WOOLLEN CLOTH MANUFACTURE.

Amongst the papers relative to French industry and commerce, published by the Foreign-office, in connection with the negotiation for an Anglo-French Treaty, is a report prepared by Messrs. Wrigley and Bousfield. These gentlemen were requested by the Council of the Associated Chambers of Commerce to visit the principal seats of the woollen manufacture in France, and the result of their observations has been accordingly placed upon record. The immediate object of their visit was carefully to examine the present condition and prospects of the woollen manufacture in France, to compare them with those of the same industry in this country, to discover wherein either country has the advantage over the other, the cause of such advantage, and, as far as possible, its extent.

Upon the primary question of capital, it was found that although the establishments are not so large, yet for an equal amount of business French manufacturers are possessed of as much capital of their own as the English, at the same time a consideration of great importance arises in comparing the requirements of capital in the two countries. A large proportion of the capital necessary for the production of a given amount of work must be laid out in machinery and buildings to contain it. Now if, in one country, machinery is worked seventy-two hours per week, and in the other fifty-six and a half hours, it is obvious that there is a great difference in the amount of capital to be invested in the machinery and buildings in the two countries to produce the same amount of work in the same time, and in this respect it was believed that a very considerable difference exists in favour of the French.

The question of power is made much of in respect to our inferiority, and great stress is laid on the advantages we have in our coal supply. But power is not procured only by steam; and while the French dwell on our advantages in steam power, much can be said as to theirs in water power. Doubtless, the proportion of steam and water power varies, not only in each district, but in each manufactory. Some mills are turned entirely by water, and in many the main force is from water, steam being used only as an auxiliary. In one district it was found that the water power amounted to as much as 80 per cent. of the whole. It is right, however, to mention that there are considerable charges on it. But the force procured, especially in districts where water power is most plentiful, is very much greater than is common with us. It is only fair, therefore, that, when the cheapness of coal in England is dwelt upon, the splendid water power of France should not be forgotten.

With regard to machinery, it must be acknowledged that, for durability and finish, English machines are superior to French. But they are dearer. Belgian machinery is still slightly cheaper than French, and in some districts is largely used. But, in estimating the value of machinery, not only must its first cost be considered, but also its durability, and the quantity and quality of the work which it turns out. As to the quality of the work, no inferiority was noticed in French machinery, which continued running as regularly, and at about the same speed, turning out about the same quantity per hour, as in England. French manufacturers make much of the superiority of English machines, but they do not largely use them, though their orders are diligently sought. It is obvious from this that they consider their home-made machines efficient, and find them more economical.

The most important of the materials used is wool, which includes Australian, German, Cape, South American, besides home grown and North African With the exception of Cape wools imported from England, and not direct, all wools used in France are duty free. There can be no doubt German wool is as cheap in France as in England. Colonial wools are, as yet, mostly brought to the wool sales in London. There the auctioneer does not stop to inquire the nationality of the buyer. All nations are on the same footing, and the same charges are made to all. If, then, wool at the docks or railway station in London is exactly the same price to English and French, there seems only the question of carriage. Our railway companies have charged hitherto for the carriage of wool from London to Leeds and Huddersfield, 40s., now 37s. 6d. per ton; to Galashiels, 42s. 6d. per ton. The cost of the transport of wool in quantities from London to Elbœuf and Sedan is only 35s. per ton, which gives a decided advantage to the French manufacturer. South American wools are much more used in France than England, and are imported direct.

The somewhat exceptional prosperity enjoyed in late years by the woollen industries in the department of the Tarne, is mainly owing to the manner in which the South American skin wools have been worked up and adapted to certain makes of goods. It is distinctly a speciality of the district. Skin wools are imported in large quantities from the River Plate, and mostly come to Bordeaux. Some wools of home growth, and some from Northern Africa, were used in the manufacture of low woollens; they are coarse and cheap, and admirably adapted for blending with the coarser mungoes. A visit was paid to one manufactory in the department of the Isère, producing 200 pieces a week, entirely composed of this material; and the reporters have no hesitation in saying these are some of the cheapest goods ever seen. They are mostly printed, and this operation, as well as the dyeing and finishing, is carried on on the premises.

The machinery in this establishment—all French, and most of it new—was, perhaps, the best adapted for the manufacture of low goods of any that came under notice in France. These materials, besides being sold for the country trade, are largely exported to the Belgian, Italian, and South American markets; and it is not surprising that the exports to those markets of similar goods with cotton warps from England should have so seriously fallen off in late years. Cotton is imported direct into Havre and Marseilles, and is, at any rate, no dearer in France than in England, and is duty free. Oil is imported from the same foreign countries as supply us, and at the same prices. Soap is made in France, and calls for no special remark. It is about the same price as in England. The same may be said of dye-wares, chemicals, soda, fuller's earth, and other materials used in various processes. The teazles used appear to be entirely of French growth. They are largely grown in the south of France, the best being those from the neighbourhood of Avignon. Upon the question of materials, Messrs. Wrigley and Bousfield were unable to find that we have any appreciable advantage over the French.

Of all the heads of inquiry none was thought of more importance, or greater interest, than labour. The value of labour cannot be judged alone by the time worked, the money paid, the work done, or the skill, taste, and education of the workman, but by all these combined. As to the length of time, there can be no question that the French work longer hours than we do. Seventy-two hours a week, or twelve hours for six days in the week, is the regular time for men, women, and children. Some of their machines, especially sets of condensers, work very long hours; such machinery was found running even 156 hours out of the 168 hours in the week. It commences working at midnight on Sunday, and works on continuously until the following Sunday at noon. In addition, therefore, to the regular 72 hours of work, in busy times, and times of pressure, Sunday work is available; even when the mill does not regularly run on the Sunday, cleaning and repairing are frequently done, which prevents waste of time during regular week-day working hours. Although, under the provisions of the Factory Acts of this country, 56½ hours per week are available, 56 hours are all that are usually worked. This, in comparison with the 72 hours worked in France, give the latter an advantage of 27½ per cent. With regard to the wages paid, it may not be fair to compare individual items only, but, generally speaking, the rates obtained, compared with those in England, show that wages in France in the woollen manufacture are, at least, 25 per cent. lower than in the United Kingdom, or that English wages are fully a third more than French. Then arises the question of skill, and it is admitted that the managers, overlookers, dyers, and foremen at the head of the French mills are better educated, and of more cultivated taste, than the generality of English managers and designers. No doubt the late Education Acts, and the present efforts to promote technical instruction, are rapidly effecting a great change in this respect. In France, not only primary, but also technical and professional education, is within the reach of the son of the poorest artisan. The advantage of these institutions is particularly felt in designing and dyeing, in both which operations it is feared we are behind our neighbours. What we call "good taste" seems to be born in Frenchmen—a source of profit, costing nothing. They also diligently cultivate harmony of colour, elegance of form, and the sense of the beautiful, all of which are so important in designing. In dyeing, the French appear to be able to produce brighter and clearer colours than we do. This may be difficult to explain. A brighter atmosphere may have some influence. There may also possibly be a difference in the water used. It cannot, however, be overlooked, that a scientific and practical education combined has greatly contributed to this result.

The French are the most ingenious people in Europe, and there are already signs of their arousing themselves to attack our supremacy in the inferior qualities, and there is no reason why they should not succeed. As to markets, the whole of France and her colonies, and the whole of England, are open to the French for their woollens, without any duty whatever. In this they have an advantage over us. A point always urged as being so much in our favour is the very large consumption of manufactured goods by our colonies. But it must be borne in mind that the self-government granted by Great Britain to her colonies includes the management of their own fiscal affairs, without any stipulations for preferential admission of the products of the mother country, the result of which is, that exactly the same import duties are levied on British goods as on French or any other foreign goods. In nearly all countries which import woollens, France is a very keen competitor with England. In some markets she has to a considerable extent displaced us. In South America, for example, her manufactures have largely superseded our own. Most important is it to notice that, since the Treaty came into operation, France has sent to England nearly twice the value of woollen piece goods that she has received from England, and she has exported to all countries three and a-half times the amount she has imported. The totals on the French official statistics, from which these calculations are made, include worsted and mixed fabrics, so that the reporters were unable to show in figures, what is generally admitted by those most conversant with the Anglo-French woollen trade, that the trade in such goods as are produced in both countries is gradually turning greatly in favour of France.

GENERAL NOTES.

The Electric Light.—The electric light was experimentally used at the London-bridge Terminus of the London, Brighton, and South Coast Railway, on the afternoon and evening of Saturday last, the 21st inst., for lighting the open space between the main line and Crystal Palace line booking offices and the platform barriers. The Gramme machine and Suisse lamp were employed; the motive power being obtained from an engine about 250 yards distant, which, in addition to working the magneto machine, also pumped up the water required for the general purposes of the station. The machine was the one shown at the Society's meeting on the 4th inst., and is one of the first of its kind made in England. The lamp is also similar to those exhibited by M. Suisse the same evening; it is said to last about twelve hours without attendance. Both lamp and machine were supplied by the India-rubber and Telegraph Works Company, of Silvertown, whose electrician, Mr. R. K. Gray, and the railway company's engineer, Mr. E. J. Houghton, assisted by Mr. Carey, carriod out the experiment.

MEETINGS FOR THE ENSUING WEEK.

MON. ...London Institution, Finsbury-circus, E.C., 5 p.m. Prof. W. F. Barrett, "The Phonograph, Tasimeter, Carbon Telephone, and other Inventions of Mr. Edison."

TUES. ...Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lectures.) Prof. Dewar, "A Soap Bubble." (Lecture II.)

THUR. ...London Institution, Finsbury-circus, E.C., 7 p.m. Prof. H. Morley, "The English Stage as it has been."
South London Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. Popular Meeting.
Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lectures.) Prof. Dewar, "A Soap Bubble." (Lecture III.)

FRI. ......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 7 p.m. (Juvenile Lectures.) Mr. W. R. S. Ralston, "The Mythology of Fairy Tales." (Lecture I.)

SAT. ......Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lectures.) Prof. Dewar, "A Soap Bubble." (Lecture IV.)

ADULT INSTRUCTION THROUGH PUBLIC MUSEUMS.

(Subsidised by Parliament.)

The following results, giving important information bearing on public education, are obtained as correctly as possible, from inquiry and Parliamentary returns, in the hope that they may hereafter be officially collected and published periodically, like the Registrar-General's returns. The number of visitors for the months of August, September, October, and November, 1878, are stated. When they are counted by sight the letter "S" is used, when by turnstile the "M":—

Institutions.	Amounts voted in 1878.	Number of Visitors in August.	Number of Visitors in Sept.	Number of Visitors in October.	Number of Visitors in Nov.	How counted.	Observations.
1. British Museum	£ 112,990	55,656	37,831	29,745	30,463	S	Return refused. Open Mondays, Wednesdays, Fridays, and Saturdays. Closed, except to students, on Tuesdays and Thursdays (1)
2. National Gallery, Charing-cross	11,983	106,245	62,644	..	..	S	Open Mondays, Tuesdays, Wednesdays, and Saturdays. Closed on Thursdays and Fridays. Open from 10 to 6. (2)
3. Kew Gardens and Museum	22,622	134,360	57,491	30,587	8,194	S	Open on Sundays & week days. (3)
4. South Kensington Museum	39,726	89,808	75,225	66,277	54,404	M	Open morning and evening till 10, on Mondays, Tuesdays, & Saturdays. Students' days—Wednesday, Thursday & Friday, 6d. entrance; open from 10 till sunset.
5. Bethnal-green Museum	7,850	45,018	38,554	35,095	29,505	M	Ditto. (5)
6. National Portrait Gallery, South Kensington	2,000	..	..	..	..	M	Return refused. Open daily except Sundays. (6)
7. School of Mines and Mining Record Office, Geological Museum, Jermyn-street	8,931	970	2,100	2,941	2,497	M	Open daily, except Sundays and Fridays, and in the evenings till 10 of Monday, Tuesday, and Saturdays. (7)
8. Patent Office Museum, South Kensington	1,800	26,576	22,517	19,129	..	M	Open daily, Sundays excepted. (8)
9. Edinburgh National Gallery	2,100	18,493	10,743	6,704	..	M	(9)
10. Edinburgh Museum of Antiquities	..	18,435	9,009	6,050	..	M	(10)
11. Edinburgh Museum of Science and Art	10,838	44,591	29,888	30,416	31,249	M	Open daily (10 a.m. to 4 p.m.) except Sundays, and Friday and Saturday evenings (6 to 9). Students' days—Monday, Tuesday, and Thursday; admission 6d.; other days, admission free. (11)
12. Edinburgh Botanic Gardens	1,750	9,126	7,567	6,554	2,276	M	(12)
13. Dublin Museum of Natural History	1,762	12,267	10,968	14,644	10,161	M	Open daily, & in the evening. (13)
14. Glasnevin Botanical Gardens and Museum	2,224	34,938	27,034	13,302	4,004	M	Open daily, including Sundays. (14)
15. National Gallery of Ireland	2,389	7,869	8,387	..	6,539	M	(15)
16. Museum of Royal Irish Academy, Dublin	200	..	..	..	..	M	(16)
17. Zoological Gardens, Dublin	500	13,622	11,389	7,858	3,366	M	Open daily, including Sundays. Number of visitors in July, 15,281. (17)
18. Tower of London	1,590	..	..	..	..	S	Open daily, except Sundays. (18)
19. Royal Naval College, including Greenwich Painted Hall	38,051	158,179	61,486	44,683	26,431	S	Open daily, including Sundays. (19)
20. Royal Naval Museum, Greenwich	1,055	13,713	7,607	4,894	1,662	S	Open daily, except Fridays and Saturdays. (20)
21. India Museum, South Kensington	..	3,166	2,526	1,551	1,068	M	Paid for by Indian Government. Open on Mondays, Tuesdays, Fridays, and Saturdays, 1d. admission; on Wednesday and Thursday, 6d. admission. (21)
22. Hampton Court Palace	7,475	..	..	..	..	..	Open on Sundays, and on week days except Fridays. (22)

(2) Open 17 public days (including one bank holiday) during August. Open 16 public days in September, from 10 till 5 o'clock. Total number of visitors for nine months, to 30th September, 785,979. The Gallery was closed for cleaning and repairs from 30th September, and again opened on Monday, the 4th November.
(9) (10) Closed for November.
(14) (15) Now sub-departments of the Dublin Science and Art Museum. Gallery closed in October.

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FRIDAY, JANUARY 3, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

DEATH OF H.R.H. THE PRINCESS ALICE.

The following has been received in reply to the address of condolence from the Council to H.R.H. the Prince of Wales:—

Mr. Knollys is desired by the Prince of Wales to thank the Council of the Society of Arts for their Address of Condolence on the occasion of the death of Her Royal Highness the Grand Duchess of Hesse.

His Royal Highness is much touched by the kind expressions of sympathy that they have addressed to him on the irreparable loss which he has sustained, as well as by the touching manner in which they have alluded to his lamented sister.

Sandringham, King's Lynn.
1st January, 1879.

CANTOR LECTURES.

MATHEMATICAL INSTRUMENTS.

By W. Mattieu Williams.

Lecture II.—Delivered Monday, December 2nd, 1878.

All our ideas of measurement are naturally and necessarily relative, and all our practical measurings are made by comparison. When we say that a thing is large or small, we mean that it is larger or smaller than some other thing either expressed or understood. If I speak of a large fly and a small elephant, I do not mean that the fly is larger than the elephant, but measure both by a standard which is supposed to be presented to the mind of everybody when the name of fly or elephant is used, that being the average fly or average elephant. This sort of ideal average is, however, a very loose and indefinite standard, quite inadmissible for scientific purposes, or even for common purposes where approximate accuracy is demanded. We require some standard which is invariable, is generally understood, and easily certified and applied.

The earliest standards of linear measurement of which we have record, were the lengths of some natural objects, such as a barleycorn taken from the middle of the ear, three of which laid end to end is said by some to be the basis of the old standard inch. Others maintain, I think correctly, that our inch was originally a thumb's breadth. This thumb breadth still exists as a measure. In the measuring of certain fabrics it is customary to give 37 inches to the yard, or a "thumb over," that is, passing the yard stick over the thumb in measuring. In the French, German, and Italian languages we find the words *pouce*, *daumen*, and *pollice*, used both for thumb and inch, and we still speak of "the rule of thumb."

All we know indicates that the earliest and most primitive standards of measurement were based on the human body, just as our decimal notation has resulted from counting by ten fingers. The handiest of unsophisticated measures for pliable fabrics, &c., is the length from the end of the middle finger to the elbow. This is the ancient "cubit." Many ladies still use it as a half-yard measure. The "fathom" (about 6 ft.), was the height of a tall man. The "digit" (about $\frac{3}{4}$ inch) was the breadth of the first joint of the forefinger. The "palm," or hand-breadth (about 3 in.), and the "span" (about 8 in.), the "pace" (about 30 in.), are ancient standards, based upon the human body.

The French foot, or "*pied du roi*," is traditionally described as the length of Charlemagne's foot, and ours that of a stalwart Saxon chief. It is about one-seventh of an inch less than the Egyptian foot. Our yard, in like manner, is said to have been the gird or girth of a warrior's waist, and later to have been adjusted by Henry I. to the full length of his own arm. Our mile is based upon the Roman measure of 1,000 paces (*millia passuum*).

Our old and almost forgotten measure, the league, was based on an hour's walk; the French league the same. In Germany it still bears the name of "stunde," or hour. In Switzerland the "stunde," or league, varies with the ground, being shorter up hill than down, in order to practically represent an hour's walk.

The Norwegian mile (a little more than seven of ours) is based on an hour's carriole drive. The Dutch boatman, who is a steady smoker, has a standard unit of his own for long distances. He measures them in pipes.

All of these are far too variable for civilised requirements. We may either select some natural object of invariable dimensions, such as the earth itself, or simply construct an arbitrary standard of some invariable material, and keep that for permanent reference. The latter is the simplest, but has the disadvantage of being liable to destruction, or loss; or it may be tampered with, if due precautions are neglected. Our British standard yard measure is of this arbitrary character. The Act of Parliament of 1824 declares that a certain metallic bar, made by Bird in 1760, shall, when at a temperature of 62° Fahr., be considered as the standard yard of the British Empire, without further reference to its origin.

The same Act provided against the loss, destruc-

tion, or injury of this artificial standard, by declaring that it shall measure 36 inches, and these inches of such length that 39·13929 of them are equal to the length of a pendulum vibrating seconds in *vacuo* at the sea level in the latitude of London.

The standard of 1760 was actually destroyed about ten years after the passing of this Act, by the burning of the Houses of Parliament, and the construction of another standard became necessary. The Government wisely determined to make this an opportunity of thoroughly revising the whole subject of our standards of measure and weight. After long deliberation, the committee appointed to examine the subject issued a report, dated December 21, 1841, throwing some doubt on the accuracy of the pendulum reduction of the Act of 1824, and recommending reference to duplicate standards still extant, rather than to the pendulum. Finally, a practical Standards Committee, composed of eminent mathematicians. with the Astronomer Royal at their head,* issued their final report in 1854, after nearly eleven years' work, during which period more than two hundred thousand micrometer readings were made in working out the various comparisons, for which an entirely new system of thermometers were made. The members of this committee, engaged upon the national standard of length, declined to accept any pecuniary remuneration for their valuable labours.

This restoration was conducted on the practical common sense basis of comparing the remaining yard measures, which there was fair reason to believe were the best representatives of the lost standard. For a history of these, and the reasons which determined their selection, I may refer to an interesting treatise on "Weighing and Measuring," by Mr. Chisholm, lately published by Macmillan and Co. I have only time to state the decisions of the committee, which were:—

1st. That the length of one yard be the standard unit of length.

2nd. That a line standard is preferable to an end standard, *i.e.*, that the distance between two lines marked on a bar is preferable to that from end to end of a bar.

That the standard be made of an alloy composed of copper, 16 parts; tin, $2\frac{1}{2}$ parts; zinc, 1 part. This is now known as "Baily's metal." It was adopted as the result of his long series of experiments for the determination of an alloy that will not rust, and has a high degree of elasticity and rigidity. The test bar, when loaded at the centre with $5\frac{1}{2}$ cwt., broke without bending.

4th. That the form of the standard be a solid bar 38 in. long and one inch square in section. The measure of a yard to be defined by the distance between two fine lines perpendicular to the axis of bar, marked upon gold studs, at the bottom of cylindrical holes drilled from the upper surface to the mid depth of the bar.

Forty standards were constructed in accordance with these decisions, and the most perfect, as regards the clearness of the defining lines and general good workmanship, was selected as the Imperial standard. It now stands, or rather lies, in the old jewel tower of Westminster Abbey, enclosed in a case of plate-glass, and that case in an outer fire-proof iron case, the keys of which are kept in charge of a highly responsible scientific officer. I was lately allowed the privilege of seeing the iron veil uplifted, and gazing upon the sacred bar through the side of the inner glass case, but not to touch it with a finger tip. Only once in 20 years may it be lifted out and used for the purpose of practical verification of the other 39 standards. Four of these are deposited in similar sanctuaries—the first is at the Royal Mint, the second in charge of the Royal Society, the third in the Royal Observatory at Greenwich, the fourth is immured in the New Palace at Westminster. These are the Parliamentary copies, or Auxiliary Standards of Reference. All of them, with the exception of the fourth, are to be compared with each other once in ten years, and with the sacred standard once in 20 years.

The other 35 bars are engaged in practical journey-work for the verification of local corporate and other important standards. At first sight it may appear that these precautions are overdone and somewhat pedantic, but this impression is refuted by the facts connected with the predecessors of the present standard. In the first place the two standards of 1758 and 1760 (both made by Bird) were practically destroyed by the burning of the Houses of Parliament, both being found among the ruins too seriously injured for reference. This is not all, for even before this, Bird's standards had suffered considerable damage by being directly used for verifications. In them the yards were measured by dots, marked upon gold studs sunk into the bars, the distance being measured by beam compasses, and laid off upon the measure to be verified. The edges of the dots thus became so much indented and irregularly worn away, that the position of the original centres was very doubtful. Mr. Baily, who examined these, early in 1834, under a microscope, describes the holes as appearing like the miniature crater of a volcano.

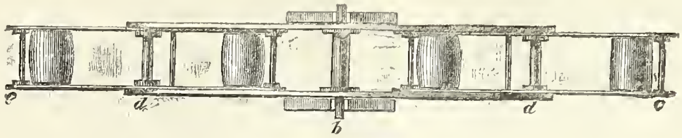
As already stated, the defining lines are marked upon gold studs at the bottom of cylindrical holes sunk to half the depth of the bar. Why not draw these lines upon the face of the bar itself? The reasons are, first, that gold does not oxidise at all; second, that by sinking the lines to the middle of the bar, the errors due to superficial expansion are eliminated.

The radiations from the body of the observer, and the condensation of the vapour of his breath upon the surface of the cold bar, produce expansion, which at first is of course superficial, and productive of flexure, and afterwards raises the temperature of the whole of the bar.

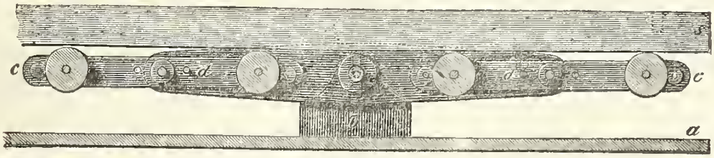
The method of comparison at present used by the Warden of the Standards is as follows:—The bars to be compared are immersed in a bath of glycerine, and each rests upon rollers. In order to prevent flexure by unequal pressure on these supports, the rollers are fixed on the ends of bars that turn on a pivot exactly midway between them. The action of the support is easily understood. Suppose that for a moment the bar should press more heavily on the right hand than on the left hand-roller of a pair, what must follow? The roller receiving the greater pressure descends or

* The members of this committee were:—Sir G. B. Airy, Astronomer Royal; F. Bailey, V.P.R.S.; J. E. D. Bethune; Davies Gilbert, V.P.R.S.; Sir J. G. S. Lefevre; Sir J. W. Lubbock; Rev. G. Peacock; Rev. R. Sheepshanks; Sir J. F. Herschel; The Marquis of Northampton; Prof. W. H. Miller; and the Earl of Ross, after the death of the Marquis of Northampton.

presses downwards, and that on the opposite side of the pivot ascends or presses upwards, and the pressure is thus at once equalised. Each of these pairs being similarly attached to the pivot, the whole system acts in like manner. Eight rollers are mounted on this principle.



Plan



Section

The trough, or bath, containing the standard, is mounted on a carriage, running on iron rails that are firmly bolted to the levelled stone floor of the old Norman Tower of Westminster Abbey. This carriage thus runs smoothly in a direction transverse to the length of the bars.

Over the ends of the bars, and standing upon a strong stone shelf fixed to the solid wall, are two microscopes of exquisite construction, with parallel or obliquely crossing spider web lines in the focus of the eye-piece. These are placed so as to look down upon the defining line, which stands between two other lines, drawn upon the gold stud, and, by a delicate micrometer screw the parallel spider webs (which are so near together that they appear to be touching to the naked eye) take this line midway between them, or the cross webs at their intersection. Having thus placed the spider-webs of the microscopes over each defining line of the standard, the carriage is now moved forward so as to bring the bar to be compared similarly under the same unmoved microscopes, and thus the most minute deviation of its defining line, from midway between the parallel spider lines, or the intersection of the cross lines, is observable; and not only seen, but is accurately measured, within $\frac{1}{1000000}$ of an inch, by turning the micrometer screw and reading its divisions.

On the occasion of my recent visit to the old tower, I had an opportunity of thus testing such a bar, and discovered, and easily measured, a discrepancy quite invisible to unaided eyes.

But how can this delicate line be thus seen while at the bottom of the little pit sunk in the bar? This is done by placing over each pit a glass prism, which receives and reflects straight down the hole the light of a lamp placed horizontally before it.

The standard temperature of comparison is 62° Fahr. If all sorts of bars expanded equally, they might all be compared at any time or season when kept at equal temperatures by means of the glycerine bath; but this is not the case, and thus it becomes necessary either to make all comparisons at the standard temperature, or make reductions for the difference due to the varying co-efficients of expansion of different metals or alloys.

This varying co-efficient of expansion of different substances corresponds to the personal equation of the different observers, what I described at the last lecture, and Mr. Chaney, to whom I am indebted for the interesting information derived from my visit to the office of the Warden of the Standards, told me that recent investigations have indicated that metallic alloys, like the observers, are subject to variations of their personal equation as they grow old; some sort of molecular settling down occurs which effects this change; a subject demanding consideration in reference to even the sacred yard measure itself.

Although the above stated refinements are necessary for the comparison and verification of the official standards of the Empire, upon which are also based those of Russia and the United States, it does not follow that every linendraper's yard stick or every carpenter's rule should be thus elaborately tested. End standards and gauges are the most convenient for these, and you have only to step across to Trafalgar-square to find upon its north wall such a standard, made by Troughton, of an alloy similar to Baily's metal, where any workman may test his rule by simply placing it between the jaws of the very substantial bronze gauge. If too long it will not enter, if too short it will shake. By the side of this standard yard-gauge there are also gauges for one foot and two feet, with inch divisions and decimals of inches; and in front and below, upon the long stone step, are inlaid bronze bands, with raised bronze gauging ends for measuring 10 feet to 100 feet, divided into inches and tenths. Also a chain gauge for 66 feet, divided into links and tenths.

The lost standard of weight was restored by the same commission, and upon the same principle of comparing it with the best obtainable copies of the original troy pound made under a Parliamentary Committee in 1758. Three others of the same date remained, but were not satisfactorily verified, and differed slightly in their volume and weight. These

others of brass and bronze were all affected by oxidation, and finally the commission determined to rely upon two platinum troy pounds, one belonging to Professor Schumacher, and the other to the Royal Society, both made in 1829.

The present imperial standard is an avoirdupois pound, a cylinder of platinum with a groove near the top. It is 1·35 in. high and 1·15 in. diameter, specific gravity 21·1572. It displaces 0·403 grains of air. As the construction, verification, and use of this involves the whole subject of weighing, they will be treated hereafter, when I shall also have to refer to the auxiliary standard of quartz.

The unit imperial standard measure of capacity, from which all other measures of capacity, whether of liquids or dry goods, are derived, is "the gallon containing ten imperial standard pounds weight of distilled water weighed in air against brass weights, with the water and the air at the temperature of 62 degrees of Fahrenheit's scale, and with the barometer at 30 inches." This is the definition given in sec. 15 of the Weights and Measures Act of the present year, 1878. The same Act, sec. 16, specifies that the bushel measure of eight gallons "shall be a hollow cylinder having a plane base, the internal diameter of which shall be double the internal depth;" the half bushel, peck, or multiples of a bushel of the same form and proportions.

The official standard for the bushel, peck, gallon, &c., are substantially made of bronze, the upper edges ground perfectly flat. The official inspectors' standards are copies of these. Their verification is conducted as follows:—The measure to be examined is placed on a stand in front and below the primary standard. This stand is a tripod, the feet of which are three screws. By means of these the measure is adjusted to an exact level, tested by a long spirit level laid across its edges. The inside is then wetted with a damp cloth, or sponge, and the contents of the standard (previously filled with water) are transferred, first by a syphon, and finally by tipping the standard, which is mounted upon an axis for the purpose. The water adhering to the sides of the standard after tipping is compensated for by the wetting above mentioned.

The striking, or determination of the exact fulness of the measure, is effected by carefully laying upon it a thick circular plate of glass, ground accurately flat. This plate of glass has a small air-hole in the centre, and this hole opens into a little cup or bowl, hollowed out of the face of the glass plate shown in section, in the figure. If the measure is exact, the surface of the water it contains just touches every part of the glass striking plate. If the measure is too large, an air-space remains between the under surface of the glass and the water. If too small, some of the water oozes through the hole, and rests in the little cup. In the first case the measure may be corrected by grinding down its edge upon a flat plate; in the second, by grinding or scraping away some part of its interior.

The French primary unit, the metre, is theoretically equal to the ten millionth part of the earth's meridian quadrant, *i.e.*, of the distance from the equator to the pole. This unit was selected in 1791 by a committee of the French Academy, at a period, when in Paris, everything was based on first principles and splendid theories. Merely arbitrary commercial standards were rejected in favour of something grander, and of immutable fixity, and, therefore, the earth's magnitude was chosen as more worthy of the great Republic. Subsequent investigations have shown that it is more difficult to measure an arc of the meridian than the length of a brass bar, and that it is easier and better to keep duplicate standards as a safeguard against destruction of the orginal, than to re-measure the earth. Such a re-measurement has been made since 1791, and the latest result gives the length of the meridian passing through Paris, as equal to 10,001,472·5 metres. Thus the standard metre is too long for the theory, and must either be shortened or the theory abandoned. As such shortening would disturb all contracts or transactions based on the original standard, the latter practical course is adopted, and the French metre, like the British yard, is simply the length of a certain standard bar. This bar is an end standard made of an alloy, of 90 parts platinum to 10 of iridium, a material which is unquestionably better than ours. The Warden of our Standards has a beautiful divided decimetre standard, made of rock crystal, a still better material than the platinum-iridium alloy, but not obtainable of as great a length as a metre (39,37,079 inches).

The great merits of the French standards are their decimal divisions, and the elegant device of basing the standard of weight upon that of length. The kilogramme, or kilo, is the weight of a cubic decimetre ($\frac{1}{10}$ of a metre) of distilled water at its thawing point and weighed in vacuum. The gramme is $\frac{1}{1000}$ of this. The multiples of the French primary standards are expressed by the prefixes of "deca," ten; "hecto," 100; "kilo," 1,000;

Section of Glass-plate used for Striking Standard Measures.

"myria," 10,000; "quintal," 100,000; "millier," million. The divisions are expressed by "deci," $\frac{1}{10}$; "centi," $\frac{1}{100}$; "milli," $\frac{1}{1000}$, &c. Thus by placing the decimal point on the right of the figure expressing the standard unit or units, any weight or measure is expressed by ordinary decimal notation, all the abominations of the "compound rules" are excluded from the primary schools of France, and a French boy or girl proceeds directly from simple arithmetic to algebra.

Besides this, in every Government office, every bank, or other house of business, about 10 per cent. of clerk's work is saved in book-keeping.

The method adopted for the exact measurement of a given cube of water will be explained when I come to the device of Archimedes.

The measurement of value, like those of length, area, capacity, and weight, is of such great commercial importance, that it has in all civilised countries been subject to Government regulation.

The value of a thing is the quantity of some other thing, or of things in general, for which it exchanges. Such value may be stated or expressed or measured, by one thing or another, quite arbitrarily; thus the value of a ton of iron may be expressed as equal to two quarters of corn; thus we should measure iron value in corn. It may be measured in copper or wool or hides, but the inconvenience of such measures is obvious, seeing that the value of the measure is itself variable. To adopt a corn standard of value would be like making our standard yard measure of india-rubber.

As value must be measured by value, just as length must be measured by length, and, as all commodities fluctuate in value, this measurement is necessarily one of considerable inaccuracy. Only an approximation to a fixed standard is possible.

What commodity, then, has the greatest fixity, or rather the smallest fluctuation of value? There is no difficulty in answering this question. It is gold.

Fluctuations in value depend upon fluctuations of supply and demand.

Gold is subject to less fluctuations of supply, because the total stock in hand is, in proportion to the annual production, larger than that of any other commodity. This arises from the fact that gold is comparatively imperishable, and has been prized and hoarded by all mankind for many thousands of years. Less is wasted than of anything else. It passes from generation to generation for ages and ages; is melted, and re-melted, and fashioned afresh almost without limit. For aught we know, the wedding ring of Queen Victoria may contain some of the very same material that formed the girdle of Cleopatra. Its demand is comparatively constant, as everybody desires to get it.

For these reasons, and its portability, its easy divisibility, its durability, its universal acceptance, and its easy recognition, it is our standard of value. We do not use pure gold, because it is too soft, but we give it a desirable hardness by alloying it with a little copper.

Standard gold is an alloy of 11 parts of gold to 1 of copper, called otherwise 22 carat gold, the goldsmith's carat being no fixed weight, but simply $\frac{1}{24}$ part of any weight; 22 carats are $\frac{22}{24}$ or $\frac{11}{12}$.

The British unit of value is a stamped, and thereby certified, piece of gold, weighing 123·27447 grains, or $\frac{1}{1869}$ of 40 lbs. troy.

The method of constructing this standard is very simple. Anybody who chooses to deposit at the Mint a bar or bars of 22 carat gold, weighing 40 lbs., may have it all coined into 1,869 sovereigns without charge, and thus becomes possessed of 1,869 imperial standard measures of value. Those who are unwilling to wait until their own particular bars are coined, may take them to the Bank of England, and obtain sovereigns in exchange for them at once, but the Bank charges a small discount for this advance, and gives 1,866 sovereigns instead of 1,869. This small discount of about $\frac{1}{6}$th per cent. is profit to the Bank, which is obliged by its charter to keep a certain reserve of gold, either in coin or bullion, to meet its notes. It saves trouble and delay to the depositor, and the Mint escapes a number of retail transactions by coining at once the large bullion accumulations of the Bank. The nation is supplied with its standard unit measures of value and medium of exchange just according to the demand for them. Shillings, pence, and all other monies are merely subdivisions of this unit.

I have already said that the value of a commodity may be measured in anything. When we measure it in money, *i.e.*, in standard gold, we call the specific measurement of value its price. Hence, although the value of gold may vary somewhat, its price cannot vary at all, for the price of gold is simply the value of gold measured by the value of gold. By the arrangements just described, the mint price of standard gold is fixed at £3 17s. 10½d. per ounce. We are very fond of grievances, and this fixing of the price of gold has been made a grievance, and "free trade in gold" demanded. The fixing of the price of gold merely means the fixing of the weight of the sovereign. If the weight of the sovereign had been exactly ¼ oz. nobody could have failed to see that with such a coin issued at its full value, the price of gold could be neither more nor less than £4 per ounce.

The actual clumsy fractional weight of our unit of value is due to the fact that it was fixed in accordance with the actual weight of the sovereign that happened to be in circulation when the law was made, just as the yard measure and pound weight were constructed in accordance with the existing standards. The sovereign, from our present point of view, is a mathematical instrument.

I may add that a halfpenny measures just one inch in diameter, and, therefore, supplies a handy pocket rule. Five shillings and sixpence weigh one ounce.

Our silver and bronze coins are not standards of value. They are mere tokens, of smaller intrinsic value than they represent. Hence, silver coins are only legal tender up to the amount of 40s., and bronze coins up to one shilling.

Our silver coins are composed of 92½ per cent. pure silver and 7½ per cent. copper, or $\frac{37}{40}$ and $\frac{3}{40}$.

The number of sovereigns and half-sovereigns circulating in the British Empire is estimated at about 170 millions sterling, equal to 1,700 tons of gold. The number of silver coins is about 700 millions, and of bronze coins about 8,000 tons, or nearly 900 millions of pieces.

This lecture was illustrated by the following standards and apparatus kindly lent for the purpose, by the Standards Department of the Board of Trade:—

Measurement of Cubic Contents.

1. Cubic foot "bottle."
2. Sir J. Smith's sphere.
3. Bushel measure and glass disc.
4. Specimen of a wet gas meter } with glass windows.
5. ditto dry ditto } with glass windows.
6. A 9 inch hollow cylinder.
7. Gallon measure.

Space Measurement.

8. Inspectors' sub-divided yard.
8*a* Dollond's yard.

Standards of Mass.

9. Quartz half-kilogram.
10. Glass 1lb. weight.
11. Nickeled brass kilogram.

Instruments for Measuring Mass.

12. Short-arm vacuum balance.

Other Instruments.

13. Appareil level. Nécessaire metrique. } Used in Normal Schools of France for teaching weights and measures.
14. And a few charts.

The following apparatus was also lent by Mr. John Browning, Strand, for the illustration of the first lecture:—

Gold leaf electroscope, spectroscope, Colonel Campbell's spectrometer, field-officer's telescope for measureing distances.

CORRESPONDENCE.

THE CULTIVATION AND CROPPING OF BAMBOO.

I quite concur in your remarks on the report of the Royal Botanic Garden, Calcutta (which appeared in last week's *Journal*), "that the question of the profitable production of bamboo shoots for paper-making seems far from settled," and in further ventilation of the question, I trust you will find space for the accompanying report which I have just received from Mr. Robert Thompson, as it materially affects the conclusions arrived at by Dr. King:—

At your request, on my return to Jamaica last spring, I continued to devote particular attention to the subject of bamboo production for paper-making, and I am glad to report with encouraging results.

While thus endeavouring to throw further light on my previous convictions, I had occasion to visit, officially, certain extensive districts of the island in which bamboo largely abounds, and in which it is regarded as an irrepressible weed, very frequently even to the exclusion of more desirable uncultivated products.

Amongst other points of inquiry, I was anxious to ascertain the condition or degree of development in which the bamboo is best fitted for cropping to answer your purposes, and this I think I have satisfactorily settled. The point is of some interest, as much misconception (vide published reports) prevails as to the proper stage of growth at which the shoots may be most economically turned to account, and whereby the maximum production of those shoots adapted for paper-making is ensured; hence a largely increased return from a given area as compared with the yield from crude, half-grown stems, and by the same mode of treatment the reproductive powers of the plant itself are invigorated.

My convictions under this head were formed at the time I visited Ford Works and witnessed your experiments of converting raw bamboo into "paper stock," coupled with the frequent discussions with you on the subject.

The condition in which the stems of this bamboo *(Bambusa vulgaris)* are fitted for cropping is readily determined by the yellowish sheaths that invest the upper portions of the stems in conjunction with the first expansion of some normal leaves which burst at the summit of the shoot. The appearance of the foliage in young, vigorous stems, is immediately followed by the precipitation or shedding of these sheaths, which up to this period characterised the young stems. The average height of these shoots, at this stage of growth, after abundant rain, ranges from 30 to 40 feet, and as the apices of the shoots, to the extent of a few feet, are quite succulent, it is necessary to remove this portion.

The stems thus divested of the tops should be separated into two, possibly three classes of material, *i.e.*, the ligneous portion towards the base to form a distinct quality from the less indurated upper portions, which produce, as you showed me, finer and more delicate fibre, and require less active chemical treatment for the conversion into "paper stock."

In consequence of the unusually prolonged rainy season, which this year began in June, heavy falls of rain having been experienced in the wetter districts of the island for months, with brief intermissions of sunshine, bamboo flourishes most exuberantly.

In the localities in which this gigantic grass largely abounds—invariably in the most humid localities—during the months of August and September, an abundant stock of young shoots was for the most part ready for cropping. I traversed hundreds of acres with an equally prolific supply, which could be continuously cropped for several months in succession.

For commercial purposes, that is, to utilise the stems in the condition you have found most suitable for paper-making material, bamboo has nowhere been subjected to systematic cultural treatment. Data are, therefore, wanting in order to test its productive power as regards the yield per acre per annum, and the proportionate extent to which continuous cropping may be resorted to.

The facts which I will now relate have a direct bearing one these points, points which exemplify the ability of the plant to reproduce large and regular crops—a view of the question not hitherto admitted by various writers.

A few years ago, some 1,300 tons of bamboo were exported from Port Morant, Jamaica, to the United States, for paper-making. All the material was obtained within a radius of a few miles; the gentleman who had the contract for supplying it for shipment received £1 per ton for the material delivered at the port. The usual price paid for felling and splitting bamboo is two shillings per cord, which when dried weighs about 700 lbs., say about six shillings per ton, thus the cutting, crushing, pressing, and carrying to the port were all performed, including the acquisition of the raw material, for £1 per ton.

The kind of bamboo that was thus utilised was matured stems, and they were felled *en masse* from every available clump. I was informed by the contractor that he commonly cut down clumps from the same stools twice in three years.

Also in another locality, some miles distance, hundreds of tons were prepared for shipment; in the latter locality (four years after the stems were felled) I carefully examined many of the stools from which the hundreds of tons were taken, and found the lofty and vigorous stems so completely reproduced that it was impossible to surmise that any distinction existed between them as regards the rank luxuriance and towering height of these stems, and the surrounding groves which had not been touched.

Numerically, however, there was a material difference between the stems produced by the four-year-old shoots, and those of greater age, the oldest possessing several times more stems.

Two months ago, owing to the preceding period of excessive rainfall, as previously referred to, there was a large stock of young shoots on the clumps which had been cut down four years previously; each of the four-year-old clumps, with an average number of 40 mature stems, possessed from eight to ten stems suitable for paper-making material. These young stems were the

result of one season's growth, and there are two seasons in the year.

The average area of each renewed clump was 576 superficial feet, say 75 clumps to the acre; each stem fit for cutting weighs fully 20 lbs.

The 40 mature stems had been produced by continuous successional sprouting, and, for all practical purposes, may be assumed as having grown at the rate of 10 shoots per annum during the four years.

These clumps had, of course, experienced a treatment quite different from the system which would ensure large and continuous cropping, namely—coppicing, it being understood that coppicing does not imply cutting down the whole of the stems or shoots to a short growth (of say two or three feet), but that such shoots only as are selected for cropping shall be cut at this height from the ground, as a certain number of stems must always be left, say one-fourth, to attain full development and to maintain the root or vegetative functions of the plant, such stems being available at subsequent cropping for fuel.

In a previous communication, I directed attention to the advantages that would accrue from the adoption of a systematic course of cultivation and irrigation on land specially selected for the purpose. Under such circumstances there can be no doubt that the yield of shoots, as compared with the returns from uncultivated stock, would be, at least, doubled per annum. Thus, the precarious seasons, and the unmethodical course of procedure implied by a chance source of supply, existing under any condition (to say nothing of irregularity of selection and extra cost of collection), would be obviated.

I was also of opinion that the St. Catherine Plain, near Spanish Town, which has been rendered irrigable by the Government for agricultural purposes, would be well adapted for the establishment of bamboo plantations. On further inquiry, however, it would appear that these lands are already specially reserved for other objects of culture, and, consequently, would be more expensive and less easily acquired than lands in most other parts of the island.

In this connection it may be observed that rivers for irrigation purposes are available in many other parts of the island, and, if the parish of St. Thomas was selected for the establishment of plantations, there is the advantage of procuring many hundreds of tons of young shoots annually from the existing stock, which can be cut, pressed, baled, and delivered at port, after making every allowance, for £2 per ton.

It would be a pity, however, to export the raw material in this state, inasmuch as great economy results from the conversion of it into "paper stock," as you propose.

Well-managed plantations of bamboo will undoubtedly yield annual returns of young stems of from 5 to 10 tons per acre, taken as dry, available for paper stock.

(Signed) ROBERT THOMSON.

14th November, 1878.

Remarking on Mr. Thomson's report, the fact should be noted that he lays special stress on the excessive rainfall inducing the exuberant growth of the young shoots of the bamboo invariably in the most humid localities, thus demonstrating that the bamboo, although not an aquatic, is essentially a water-loving plant; indeed, all my investigations bear out this conclusion, not only that a heavy rainfall is needed to induce productive growth, but that the plant flourishes best in the vicinity of rivers and streams, and on slopes abutting thereon, where the atmosphere naturally, especially in a hot climate, "would be humid."

It is therefore probable, seeing that the locality of the Botanical Garden, Calcutta, has an average rainfall of only 50 inches, this fact may have materially influenced the growth of the bamboo clumps on which Dr. King made his experiments, although, under the most favourable conditions, the system adopted of cutting down all growth pertinaciously, every successive season, could hardly fail to impede, if not destroy, the ordinary vegetative functions of the plant.

THOMAS ROUTLEDGE.

Claxheugh, Sunderland,
22nd December, 1878.

GENERAL NOTES.

Training Teachers for Music in Elementary Schools.—The first competition for ten Free Scholarships, offered by the Lancashire Musical Association, was held by Mr. Hecht, the lecturer on Music in the Owens College, on Saturday, the 21st December, at Owens College, Manchester. There were 25 competitors, and 12 were selected as most eligible. This is the first step which has been taken to convert "singing," in elementary schools, into "music," according to the advice of Mr. Hullah.

Swimming Prizes.—The annual meeting of the Youths' Institute, Old Pye-street, Westminster, was held on Wednesday evening, the 10th December, Sir Robert Carden presiding. The institution, from the report, appears to be in a very flourishing condition, and is doing good educational work in a neighbourhood where it is much needed. Amongst other prizes for competition is a silver medal for swimming offered by Mrs. Barker-Harrison. This would seem to be a very popular pursuit among the youthful members.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at Eight o'clock. :—

JANUARY 15.—"Economy and Safety, by the Use of Automatic Couplings, on Railways." By T. A. BROCKELBANK, Esq. F. J. BRAMWELL, Esq., F.R.S., will preside.

JANUARY 22.—"The Modern Science of Economics." By HENRY DUNNING MACLEOD, Esq., Barrister-at-Law.

JANUARY 29.—"The Distribution of Disease popularly considered." By ALFRED HAVILAND, Esq., M.R.C.S.E.

FEBRUARY 5.—"The Best Methods for Improving the Condition of the Blind." By Dr. T. R. ARMITAGE.

FEBRUARY 12.—

FEBRUARY 19.—

FEBRUARY 26.—"Indian Pottery at the Paris Exhibition." By GEORGE BIRDWOOD, Esq., M.D., C.S.I.

MARCH 5.—"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By JOSEPH J. POPE, Esq., M.R.C.S., L.S.A.

MARCH 12.—"The Compensation of Time-keepers." By EDWARD RIGG, Esq., M.A.

MARCH 19.—"Economical Gardens for Londoners." By W. MATTIEU WILLIAMS, Esq., F.R.A.S., F.C.S.

MARCH 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor BARFF, M.A.

Chemical Section.

Thursday Evenings, at Eight o'clock.

January 30.—"Gas Illumination." By Dr. Wm. Wallace, F.R.S.E.

Indian Section.

Friday Evenings, at Eight o'clock.

January 17. — "Affghanistan." By C. E. D. Black, Esq. Col. H. Yule, C.B., R.E., will preside.

January 31.—"Quest and Early European Settlement of India." By George Birdwood, Esq., M.D., C.S.I.

February 21. — "The Trade of Central Asia." By Trelawney Saunders, Esq.

March 7. — "The Moral and Material Progress of India." By H. Phillips, Esq.

African Section.

Tuesday Evenings, at Eight o'clock.

January 21.—"Retrospect and Prospect in Egypt." By B. Francis Cobb, Esq.

February 4.—The Opening of the District to the North of Lake Nyassa, with Notes of a Recent Expedition through that Country." By H. B. Cotterell, Esq.

March 18.—"Some Remarks upon an Old Map of Africa contained in Janson's Atlas, published at Paris in 1612." Communicated and exhibited by R. Ward, Esq.

April 1.—"The Contact of Civilisation and Barbarism in Africa, past and present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

Cantor Lectures.

Monday Evenings, at Eight o'clock. First Course, on "Mathematical Instruments." Six Lectures, by Mr. W. Mattieu Williams.

Lecture V.—January 20, 1879.

Instruments for Measuring Mass.—The scale beam—The steel yard — The spring balance — Laboratory balances—Cavendish's torsion balance for weighing the earth—Weighing the earth by plumb-line—Weighing the earth by pendulum. *Instruments for Measuring Short Intervals of Time and Great Velocities.*—Wheatstone's and Foucault's mirrors—The chronograph—The spectroscope as applied to the measurement of velocities.

Lecture VI.—January 27, 1879.

Instruments for Recording or Representing Results of Mathematical Processes.—Plotting and Drawing Instruments.

These lectures will not be addressed to mathematicians, but the subject will be treated in simple and elementary forms; any technical term that must necessarily be used will be explained when introduced.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Household Sanitary Arrangements." It will consist of Six Lectures, to be given on the following dates:—

February 17, 24, March 3, 10, 17, 24.

The Third Course will be by Mr. W. H. Preece, on "Recent Advances in Telegraphy." It will consist of Five Lectures, to be given on the following dates:—

April 21, 28, May 5, 12, 19.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon. ...Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. Hedley, "Cartage and Station Terminals."
Institute of Actuaries, The Quadrangle, King's College, W.C., 7 p.m. Professor Pell, "The Rates of Mortality in New South Wales, with a Note on the Formation of Commutation Tables."
Medical, 11, Chandos-street, W., 8.30 p.m.
Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. Mr. J. C. Southall, "The Lapse of Time since the Glacial Epoch determined by the Date of the Polished Stone Age."
London Institution, Finsbury-circus, E.C., 5 p.m. Prof. H. Maudsley, "Organisation and Moral Feeling."

Tues. ...Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lectures.) Prof. Dewar, "A Soap Bubble." (Lecture V.)
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m. Annual Meeting.
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Rev. S. J. Whitmee, "Revised Nomenclature of the Inter-Oceanic Races of Men." 2. Mr. W. G. Lawes, "Ethnological Notes on Koitapu, Motu, and neighbouring tribes of New Guinea."
Biblical Archæology, 33, Bloomsbury-street, W.C., 8½ p.m.

Wed. ....Geological, Burlington-house, W., 8 p.m. 1. Prof. R. Owen, "Description of Fragmentary Indications of a huge kind of Theriodont Reptile (*Titanosuchus ferox*, Ow.), from Beaufort West, Cape of Good Hope." 2. Mr. J. Clarke Hawkshaw, "Notes on the Consolidated Beach at Pernambuco." 3. Mr. Patrick Doyle, "Some Tin Deposits of the Malayan Peninsula."
Graphic, University College, W.C., 8 p.m.
Microscopical, King's College, W.C., 8 p.m. 1. Mr. W. J. Sollas, "Observations on *Dactylocalyx puniceus*, with a description of a new variety, *D. Stutchburgyi*." 2. Dr. Edmunds, "Note on a Revolver Immersion Prism for Substage Illumination." 3. Mr. J. Mayall, "An Appliance for Substage Illumination." 4. Mr. F. Kitton, "The Thallus of Diatoms."
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. 1. Mr. Carmichael, "Reubens and the Antwerp Art Congress." 2. Mr. Brabrook, "An Unrecorded Event in the Life of Sir Thomas More."
Obstetrical, 53, Berners-street, Oxford-street, W., 8 p.m. Annual Meeting.

Thur. ...Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 7 p.m. Prof. H. Morley, "The English Stage as it is."
Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lectures.) Prof. Dewar, "A Soap Bubble." (Lecture VI.)
Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.
Royal Historical, 11, Chandos-street, W., 8 p.m. 1. Miss Helen Taylor, "Some Characteristics of Celtic Settlements on the Borders of the Mediterranean." 2. Dr. Robert Gordon Latham, "Early History of Hungary."
Mathematical, 22, Albemarle-street, W., 8 p.m. 1. Prof. Cayley, "A Theorem in Elliptic Functions." 2. Prof. H. J. S. Smith, "A New Modular Equation."

Fri. ......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 7 p.m. (Juvenile Lectures.) Mr. W. R. S. Ralston, "The Mythology of Fairy Tales." (Lecture II.)
Astronomical, Burlington-house, W., 8 p.m.
Quekett Microscopical Club, University College, W.C., 8 p.m.
Clinical, 53, Berners-street, W., 8½ p.m. Annual Meeting.

Sat. ......Central Co-operative Board (at the House of the Society of Arts), 6 p.m. Conference on Co-operation respecting the Working Classes.
Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

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FRIDAY, JANUARY 10, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

JUVENILE LECTURES.

The first of the two Juvenile Lectures was delivered by Mr. Ralston on Friday evening, the 3rd inst., on the "Mythology of Fairy Tales." The second Lecture will be given this evening.

CANTOR LECTURES.

MATHEMATICAL INSTRUMENTS.

By W. Mattieu Williams.

Lecture III.—Delivered Monday, December 9th, 1878.

In the last lecture I described some of the units and standards that are used for the measurement of space, of values, and of one of the physical forces, viz., gravitation.

As already stated, mathematical science grapples with all the forces of nature and struggles to describe them quantitatively. The weapons, or instrumental devices, or even the mere units and standards that are employed in these efforts, are so diverse and numerous, that I can only find time to take one more of the physical forces as an example, and for this purpose select the most familiar, viz., that which we commonly describe as "heat."

Just as our primary ideas of gravitating force are derived from our sensations of muscular effort, so are our primary ideas of heat dependent upon our sensations of temperature.

That these sensations are of but small value for measurement of temperature is easily tested by taking three basins, and in the first, placing water as hot as the hand can bear; in the second, cold water; and, in the third, a mixture of equal quantities of the hot and cold water. Then, immerse one hand in the first, the other in the second, and after holding them there a few minutes plunge both into the third. This same water will appear hot to one hand and cold to the other.

We must, therefore, find for mathematical purposes some other general effect of temperature which is more measureable, and more consistent than our direct sensations. Such is afforded by the increase of the bulk of bodies which accompanies elevation of temperature. I shall call this "expansion," rather than adopt the more fashionable, but barbaric and painfully un-English word, "dilatation."

The common thermometer is an instrument constructed for the measurement of this expansion, which may be of a gas, a liquid, or a solid, and we have, accordingly, air thermometers, mercury thermometers, spirit thermometers, sulphuric acid thermometers, metallic thermometers, &c., specimens of which, kindly lent by Mr. Casella, are on the table. To enter upon the details of their construction, and the reason for selecting these diverse materials according to the applications or range of temperature to be measured, would demand an exposition of the laws of heat. I can, therefore, only briefly explain some leading features in the construction of the most important and largely used class of thermometers, and define the standard of temperature.

As we well know, the ordinary expansion of water in a tumbler or other common vessel is too small to be easily visible. It amounts to only $\frac{1}{23}$ between its freezing and boiling points; that of mercury is but $\frac{1}{55}$ in the same range. By causing a wide vessel to overflow into a narrow one connected with it, we can so elongate this small proportion as to render it easily measurable. An ordinary thermometer tube is such a narrow vessel so connected; its bore is of thread-like slenderness, and its bulb is comparatively of great capacity. If the bulb is filled with liquid, and then by a rise of temperature the liquid is made to overflow, this overflow is caught in the tube, it is there outstretched, and its expansion is visually (though of course not actually) magnified for the purposes of inspection and measurement. Strictly speaking, the actual expansion is not thus indicated, because the glass vessel itself also expands, though in a much smaller degree. The visible expansion is the difference between that of the mercury and the glass.

As temperature is progressive, and has neither beginning nor ending, so far as our knowledge goes (absolute zeros of temperature have been imagined but never physically demonstrated), we must select a starting point of natural and invariable temperature. Two such were suggested by Sir Isaac Newton, viz., the temperature of melting snow or ice, and that of pure water boiling under a given atmospheric pressure.

These supply us not only with fixed starting points, but also with a definite distance, or range of temperature, between them. This interval between the thawing of ice and boiling water is the universally adopted unit of temperature. It is a natural, fixed, and easily definable and verifiable quantity. The "degrees" of our thermometer scales are artificial and arbitrary subdivisions of this natural interval.

In the Centigrade scale it is divided into 100 parts; in Reaumur's scale into 80 parts; in Fahrenheit's scale into 180 parts, with an imaginary and false zero at 32° below thawing point.

I need scarcely say that the first essential to the accuracy of a thermometer is that the tube shall be of equal capacity throughout, or, if variable, that the graduation shall vary accordingly. This is tested by the process called "calibration," *i. e.*,

by passing into the tube a little mercury, say sufficient to measure half an inch when in the tube, then by running this along the tube, and measuring it at different parts, any irregularity of bore will be at once seen by variations of the length of this little mercurial stick. It must become shorter where the tube is wider, and lengthen where it is narrower. The best thermometers are graduated accordingly. The length of the degree in any particular instrument is, of course, determined by the relation of the bore of the tube to the contents of the bulb, and this (after calibration) is tested by immersing it, when filled, first in a mixture of ice and water, marking the height of the thermometer there, and then in the vapour of boiling water under the given atmospheric pressure, and marking again the height thereby attained. The interval between these is then divided to the scale required. Only standard thermometers are thus directly marked; ordinary thermometers are graduated by comparison with the standard instruments when both are exposed to the same temperature. In Mr. Casella's workshop is a tank with glass sides, heated from below, the water in which may be violently or thoroughly agitated by means of dashers worked by a treadle. The best instruments, next to the "natural standard" thermometers, are compared with the standard by immersing both in this. Ordinary instruments are graduated by comparison in the air of a suitable apartment.

We commonly call these fixed points the freezing and boiling points of water, but I think it would be more correct to call them the thawing and condensing points of water, seeing that if water is kept at rest in a smooth vessel it may fall many degrees below thawing point before it freezes. A rapidly flowing river may do the same. Water may also be raised many degrees above its condensing temperature before it boils. The thawing and the condensing temperatures are not thus variable.

My proposed innovation is further justified by the manner in which these fixed points are actually and practically determined in the fundamental standardising of thermometers.

The first point is fixed, not by immersing the thermometer in freezing water, but in water cooled down by the thawing of ice. Small fragments of ice are agitated in the midst of distilled water, and the thermometer receives its temperature from the water that is doing the work of thawing, and which is cooled thereby. Formerly, the "boiling point" was determined by immersing the bulb of the standard thermometer in boiling distilled water, but Mr. Casella informs me that, more recently, when the demands of science required subdivision to small fractions of the conventional degrees, the best makers found, in spite of every precaution, serious discrepancies upon making severe comparisons between the boiling point thus determined on such delicate thermometers—that is, on thermometers in which the stem tube is so fine in proportion to the bulb that there shall be half an inch or more between each degree, and this divided into small fractions.

This discrepancy has been overcome by immersing the thermometer in the vapour of water instead of the water itself, by using an apparatus in which the thermometer is above the water, and is heated by the condensation of the vapour upon its surface. To prevent any loss of heat by its own radiation, the tube surrounding the bulb is double, and the steam occupies the jacket space between the two tubes, as well as the inside of the inner tube.

The filling of a thermometer bulb through so small an aperture as its capillary tube appears at first sight a difficult task, but it is easy enough. The bulb is heated and some air expelled by its expansion. Then the end of the tube is immersed in mercury, and as the bulb cools, some of the mercury is forced by atmospheric pressure to occupy the space vacated by the air previously expelled. This is repeated, and the mercury is heated to boiling if necessary, and the tube entirely filled upon the condensation of its vapour. Finally, the filled tube is raised to just the highest temperature it is intended to indicate, and a blow-pipe jet of flame is thrown upon that part which corresponds to the graduation for this maximum temperature. As the glass fuses it is drawn out and asunder there, and is sealed while quite full of mercury. On the cooling down and contraction of the mercury, the space left above it in the tube is thus a vacuum, so far as air is concerned.

The existence of such a vacuum may be tested by simply inverting a mercurial thermometer. In a vacuum the mercury runs freely down to the end of the tube, if the bore is of moderate size, if large, it even falls with a "click." If the bore is very small, a jerk is necessary to overcome the adhesion of the mercury to the sides of the glass.

The bulbs are blown by sealing (*i.e.*, melting together) one end of the tube, then heating that end, and blowing it out while red hot. The accuracy with which this is done by the glass blower is marvellous. He can regulate the size of the bulb to that of the diameter of the tube so nearly, that grosses of common thermometer tubes are blown to suit grosses of ready engraved scales, and the same man can blow for a scale $\frac{1}{8}$th of an inch to a degree, $\frac{1}{10}$th, $\frac{1}{20}$th, and so on as required, and do it within a very small range of error.

Another curious fact is, that these men, with very few exceptions, are Italians, or of Italian parentage, and not only do they all come from Italy, but from one part of Italy. They are Milanese, and they make barometers and other glass philosophical instruments demanding quantitative accuracy.

The founders of the trade were Tagliabue and Pastorelli, whose names may still be seen on old barometers. Among their pupils and worthy successors are Messrs. Negretti and Zambra, and Mr. Casella, to whom we are indebted for the loan of the instruments before you. These and others are naturalised and patriotic Englishmen, though bearing Italian names and worthily proud of their Italian parentage.

The neighbourhood of Hatton-garden was the original place of settlement of these scientific Italian artisans, and thereabouts they are still to be found. They and their humbler artistic compatriots have established a curious little Italy here, and across Holborn, around Leather-lane.

There is a multitude of other thermometric devices, self-registering and otherwise, in which air or other liquids take the place of the mercury. Many such are on the table, but time does not permit me to describe them. There are good

reasons why mercury is preferred for all ordinary purposes.

1st. It is a better conductor of heat than any other available liquid. The importance of ready conduction may be shown by the simple experiment of passing the bulb of any thermometer rapidly through the flame of a spirit lamp. The indicating liquid will at first fall in the tube and afterwards rise, as though the contact of the flame lowered the temperature, and emergence from the flame raised it. This apparent paradox is due to the expansion of the glass before sufficient time has elapsed for the heat to be communicated to the mercury. A water, spirit, acid, or glycerine thermometer receives the heat much more slowly than the mercury. 2nd. The quantity of heat required to raise a given bulk of mercury one degree is less than half of that demanded for raising temperature of the same bulk of water to the same extent.

A third and very important advantage of mercury is the great range between its freezing and boiling points. It is obvious that a water thermometer would be useless for any temperature below its freezing point or above its boiling point, but this is not all. It would not do even to approach these, for all liquids, and more especially water, are subject to serious irregularities in their co-efficients of expansion (*i.e.*, the amount of expansion produced by a given increase of temperature) as they approach the temperature at which they solidify or vaporise. They are only available for a certain middle range between these, and they vary a little even then, expanding rather more for each degree as the temperature rises. In the case of mercury, its expansion from 0° to 1° Centigrade is 179 millionths; between 350° and 351° it amounts to 197 millionths, progressively advancing between these.

Those large public thermometers displayed on the door posts of opticians and other shops, are usually filled with sulphuric acid, which has a much greater range than water, between freezing and boiling.

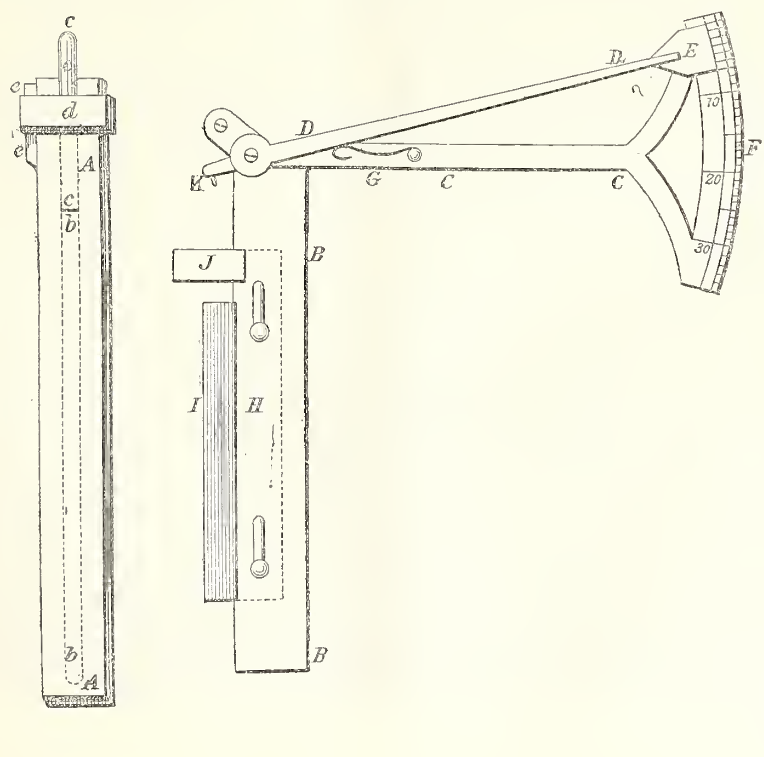
Alcohol is used for temperatures approaching or falling below the freezing point of mercury.

As gases expand so much more than mercury for a given increase of temperature (above 18 times as much, and all gases alike), and as they expand more uniformly than liquids, it might be supposed that air thermometers should be commonly used.

The principal reason why air is so little used as a thermometric indicator is, that in common with other gases it is almost, if not quite, a non-conductor of heat, and that radiant heat may pass through it so largely as scarcely to affect it.

This form of air thermometer with two bulbs connected by an U-shaped tube, in which is a bar of coloured liquid midway between the bulbs that is driven down the stem of the warmer bulb and up that of the cooler, is Leslie's differential thermometer, which did good service in the hands of its inventor, but is now almost superseded by the *Thermopile*, a small thermo-electric battery, which developes an electric flow when one face is made warmer than the other; the electric disturbance being rendered evident and measurable by the deflection of a magnetic needle. For the measurement of temperatures too high for the mercurial

FIG. 3.



thermometer solids are used. These are called pyrometers, or "fire measures." That on the table contains an iron rod, which is plunged in the furnace wherever the heat is to be measured, and its expansion pushes a rack, or a toothed quadrant, which acts upon a toothed wheel which turns the index of this dial. Wedgwood's pyrometer is based upon the drying and consequent contraction of small sticks of moistened china clay.

Daniell's pyrometer shown in Fig. 3 consists of two parts, the register and the scale. The register is a bar of blacklead earthenware, A A, in the axis of which is drilled the hole, *b b*. A rod of iron or platinum fits loosely in this, and on its upper end rests a rod of porcelain, *c c c*, held firmly, but not immoveably, by the platinum strap, *d*, the pressure of which is regulated by the wedge, *e e*. It is evident that when this is bodily put into a fire, the metal rod, which is 6 in. long, will expand, and, as the metal expands much more than its earthenware bed, it will push up the porcelain rod, and make it project further than when cold.

To measure the amount of this expansion, the scale is used. This consists of a brass frame, B B, to which is attached the divided arc, F, by the arm, C C. Traversing this arc is a vernier, E, which, when not in use, is pressed up to zero by the spring, G, working against the arm, D. At K is a projecting steel point, which touches the centre of the end of the porcelain rod, C, when the register is set against the scale, which setting is effected by adjusting J upon the shoulder of the platinum strap, and at the same time resting the face and side of the body of the register A A against its bearings I and B.

It will easily be seen that, by adjusting the scale so that the steel point at K shall rest on C when the register is cold (*i.e.*, at the pre-arranged starting or zero temperature, which may be varied as convenient), and the vernier is at zero, that the elongation of the metal rod over and above that of its bed will be measured by replacing the register on the scale, and reading the vernier, when the point K, raised by depressing the vernier, now comes down upon the centre of the porcelain rod. This reading is, of course, made after the register has cooled down again; and the porcelain rod is confirmed in its projected position by carefully clamping or wedging the strap D.

The Rumford Medal of the Royal Society was awarded to Professor Daniell for the invention of this pyrometer. It is, perhaps, the best we have, but is very little used. A simple, reliable, and practically convenient pyrometer is still wanted.

The cause of our sensations of heat was formerly described as a subtle imponderable fluid, to which the name of "caloric" was given. It is now regarded as an activity of matter itself, or by some highly imaginative mathematicians, as the activity of a supposed etherial and very vivacious something surrounding the supposititious atoms, or molecules of matter.

I cannot discuss these theories here, and only name them to indicate that the temperature measured by thermometers and pyrometers is not the heat itself, but one of its most obvious effects. If the rise or fall of temperature were always proportional to the quantity of heat transmitted, temperature would serve as a measure of heat, but such is not the case. The amount of heat force demanded to raise 1 lb. of water 1° will raise 1 lb. of mercury or platinum 30°, or 1 lb. of iron 10°. If 1 lb. of mercury at 70° be agitated with 1 lb. of water at 39°, the temperature of the mixture will be 40°, the mercury having lost 30° in raising the water 1°. With equal bulks, the mercury will lose more than twice as much as the water gains.

If two thermometers, with blackened bulbs, and of the same size, be filled, one with mercury and one with water, both raised to the same temperature, and equally exposed to radiate and thus cool down, the mercurial bulb will cool down twice as fast as the water bulb, though both give out equal heat in equal times. In like manner, if both were exposed equally to some steady source of heat, such as the flame of a small lamp, the mercury, while asorbing the same amount of heat as the water, would gain more than twice as much temperature. The temperature of one body is therefore not a heat-measure as compared with the temperature of another.

Some kind of work demanding a constant expenditure, or exertion of heat-force, is required for measuring quantities of heat, or "calorimetry" as it is termed.

The thawing of ice, the boiling of water under stated conditions, or simply the raising of the temperature of a given quantity of water, are conveniently used for this.

I have here a calorimeter invented by Mr. Lewis Thompson, and constructed with its appliances by Mr. Jonathan Wilkinson, of Grimesthorpe, Sheffield, which is of considerable practical value, and deserves to be better known than it is. Gas engineers understand and use it, as it is described by Mr. Samuel Clegg in his classical treatise on gas-making. I have used it myself in Sheffield and found it practically satisfactory. I had to send to Sheffield for this, not being able to get one in London.

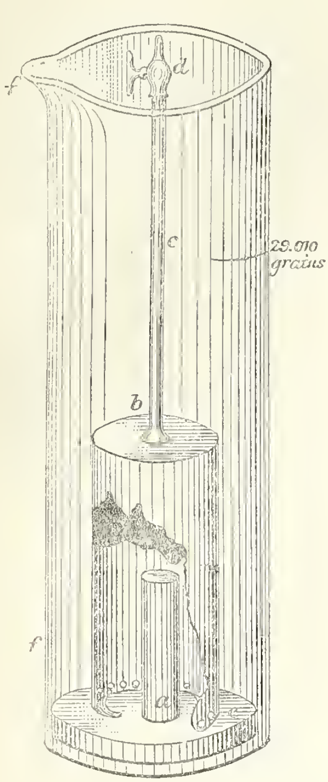
Its purpose is to determine the calorific value of any given sample of fuel, coal, wood, coke, charcoal, gas tar, petroleum refuse, &c., by simply burning a fixed quantity of the fuel under a fixed quantity of water, and measuring the heat resulting from its combustion by the rise of temperature of the water.

The apparatus consists of a stout copper tube, *a*, (Fig. 4), about three inches long and ¾ inch in diameter, closed at one end. This is the furnace. A cover, *b*, of thin sheet copper, six inches high and two inches diameter, closed at the top, and with a tube and stop-cock rising from it, *c d*. The cover is perforated with holes all round near the bottom, which is open. The furnace, when in its place, rests upon a copper stand, *e*, which is readily attached to the cover by a spring catch of sufficient strength to allow the furnace and stand to be lifted with the cover by the tube *c*.

The copper tube or furnace is charged with 30 grains of the coal or other fuel to be examined, finely powdered. This is mixed with ten or twelve times its weight of a mixture of three parts chlorate of potash and one part nitre, finely powdered, and carfully dried and rammed into the furnace. A small fuse of cotton cord, boiled in a saturated solution of nitrate of lead, about half an inch long and well dried, is partially buried in the mixture.

The glass cylinder, *f f*, is now charged with 29,010 grains of water, the temperature of which is noted. The fuse is then lighted, placed on the

FIG. 4.



stand, *e*, the cover *b* sprung over it, and the whole immersed in the water. Presently ignition commences, volumes of white fumes pour through the holes round the bottom of the cover, rise through the water, and effectually agitate it.

When the ignition ceases, the stop-cock is opened, the water rises into the cover, which should be gently moved up and down to give out its heat to the water. Then the increase of temperature is noted.

The quantities here stated as used for coal testing depend upon the following principles:—1st. That the latent heat of steam is 967° Fahr. 2nd. That coal burnt in oxygen evolves the same amount of heat as when perfectly burnt in atmospheric air. Admitting the latent heat of steam to be 967°, it follows that if we heat 967 parts of water one degree, we have employed as much heat as would have boiled off one part of water from 212°, and the same for any other rise of temperature of the water. As 30 grains of fuel is used, the quantity of water required to fulfil these conditions is $967 + 30 = 29{,}010$ grains, to which quantity the glass cylinder is graduated.

The per-centage of heat absorbed by the apparatus should be added to the calorific result.

As before stated, I have used this apparatus, and found its results very satisfactory for practical work; but regarding it theoretically, I believe that it understates the absolute calorific power of the fuel, inasmuch as some work is done and a corresponding amount of heat is lost in dissociating the oxygen of the nitrates and chlorates, and also in expanding it from the solid to the gaseous form. The heat which in ordinary open-air combustion is converted into mechanical force in expanding the nitrogen against atmospheric pressure has, however, to be set off against this. The difference bearing a constant proportion to the calorific energy of the fuel, it does not affect practical estimates of the relative value of different samples of fuel.

The calorimeter of Lavoisier and Laplace is a vessel surrounded by a jacket of pounded ice. This vessel is also filled with pounded ice, and in the midst of this ice is an inner vessel, filled with dry ice, which surrounds the substance to be examined. As the substance cools down to the temperature of thawing ice, it gives out its heat to the ice in contact with it, which is protected from external heat by the double ice jacket. The water that flows out by a tap from the inner vessel is measured, and indicates the amount of heat given out by the body under examination.

In this case, the heated body produces no rise of temperature, the ice-water being of same temperature as the ice itself. All the calorific energy it gives out in cooling is expended upon doing the work of liquefaction, which demands as much heat as would raise the temperature of liquid water 142° Fahr. or 78·8° Centigrade.

Other calorimeters have been constructed on the principle of ice melting. My own experience, as far as it goes, is decidedly in favour of the simple method of immersion in a given quantity of water, provided previous experiments have been made to determine the loss of heat by absorption of the apparatus, and its radiation, and corrections be made accordingly. Regnault, who may fairly be regarded as one of the most accurate and reliable quantitative investigators of specific heat and other calorimetric problems, adopts this principle.

I regret the necessity of passing over the subject of photometry and electric measurements. As regards the latter, I should scarcely dare to venture upon it, even if time permitted. Thirty years ago, or thereabouts, I made a special study of electricity, but have subsequently neglected it. Now, on taking up a modern treatise, I find myself in the condition of Rip Van Winkle, so far as electrometry, or the mathematics of electricity, is concerned. Quite a new science, with a new language of its own, has sprung up within that period, mainly to meet the demands of telegraph engineering.

I must now return to the instruments for space measurement. This rather ungainly instrument, by no means suggestive of mathematical precision, is the "Gunter's chain," or "Land chain," of 100 iron or steel links; each link, with connecting rings, measuring 7·92 inches; the whole chain 66 feet or four poles. At each tenth link is a brass tab, so shaped and notched that it indicates the number of tens.

Why this odd length? Its object is to supply the land surveyor, for whose use it is designed, with the basis of a decimal notation. An English acre measures 4,840 square yards; the square of 66 feet or 22 yards is 484 square yards. Thus a square

chain is one-tenth of an acre, or ten square chains equal one acre. The Gunter's chain is thus the surveyor's unit of superficial measurement, by the use of which he can record and work out all his acreage results in simple arithmetic. Would that arithmetical civilisation had similarly penetrated the rest of the British community!

The chain form, with its triple connecting rings of metal, is designed for the work of dragging over rough ground, or through grass and weeds, which would destroy a tape or obliterate ordinary graduations.

These ten skewers, or "arrows," as they are called, made of strong iron or steel wire, and 12 in. to 15 in. long, are used as tallies, thus—

Two persons, at least, are required to use the chain, a leader, and a driver or follower. The leader, carrying all the arrows, drags the chain forward, guided by signs from the driver, who sights the station poles, or other marks which determine the direction of measurement, and holds fast his end of the chain. When the leader reaches the stretch of the chain, which he settles by shaking and pulling to ensure a straight line, he thrusts No. 1 arrow into the ground so that it touches the inner side of the end ring or brass handle of the chain. He leaves it there and advances, the driver following, and still holding his end of the chain until he reaches the arrow. He now passes his terminal ring, or brass handle, over the arrow; the chain is again stretched and directed, and the leader fixes No. 2 arrow as before. The driver or follower now picks up No. 1 arrow, and both advance as before until all the ten arrows have changed hands, and ten chains are booked, and a new start is made, supposing the line to be measured is longer than ten chains. If short, of course the number of arrows in the hand of the driver is counted, and the odd links added.

The "Perambulator" is a wheel of known circumference which is run over the ground to be measured, and which, by clockwork, registers on a dial the number of revolutions. These little pocket instruments, the "pedometer" and "passometer," record the number of steps taken by means of a horizontally balanced pendulum which is shaken down at every step, and thereby actuates the train of wheels that register the number of oscillations on this dial, just as the oscillations of the balance wheel are registered in an ordinary watch.

I need not add that these are but rough measurement, only available for ordinary approximations; the more accurate instruments and methods of land measurement will be the subject for the next lecture.

The lecture was illustrated by the following apparatus lent by Mr. Casella:—

Natural standard thermometers.
Secondary standard thermometers.
Self-registering maximum and minimum thermometers.
Pedestal thermometer.
Deep sea self-registering thermometer.
Clinical thermometers.
Pyrometer, hypsometer, pedometer, and passometer.

Errata.—In the report of Second Cantor Lecture, on line 31, col. 2, page 86, for "long," read short. On line 32, for "shortened," read lengthened. On line 33, for "shortening," read lengthening.

MISCELLANEOUS.

THE SILK INDUSTRY OF NORTHERN ITALY.

By E. T. Blakely, F.S.S.

The vast importance of the silk industry from a national, industrial, and artistic point of view cannot by any possibility be over-estimated. What the tea plant is to China and the Himalayas, the coffee and cinnamon to Ceylon, the vine to France and Germany, the hop gardens to Bavaria and Kent, such is the silkworm to Northern Italy. The growth of the mulberry, the nurture of the worm itself, the unwinding of the delicate gauzy substance from the cocoon, the spinning and twisting the same into a glossy and elastic thread—wherein the perceptive faculties of the workers are brought into activity—the wealth represented by the accumulated bales of silk rendered into a condition for barter, the numerous transactions between the merchant and his home or foreign clients, the monetary operations upon the exchange wherein the banker plays a considerable part, the reflux of capital in return for the exports to the foreigner and the consequent addition to the wealth of the country; when we consider these varied points of interest, either separately or in combination, and reflect upon the effect of their ramifications, it is not surprising that the cities of Northern Italy have for many centuries maintained a historic pre-eminence; or, that the slopes of the mountains and the borders of the lakes, where the silkworm has found a congenial home, should present the appearance of a garden cultivated with the utmost care that science and art gives to the embellishment of nature.

The Chinese appear to have been the first cultivators of the mulberry for feeding silkworms, and they are supposed to have discovered the art of making silk 2,700 years B.C., in the reign of the Emperor Hong, whose empress, Si-ling-chi, is said to have first observed the labours of the silkworms on the mulberry trees, and applied their silk to use. From China the art passed into Persia, India, Arabia, and the whole of Asia. The caravans of Seres or Serica (the part of China where the silk was most abundantly produced) performed long journeys of 243 days from the "far coasts" of China to those of Syria. Aristotle was the first European to learn the true origin of the wrought silk brought to him from Persia on the return of the victorious army of Alexander from that country. He describes the silkworm as a horned insect passing through successive transformations, and producing *bombykia*, the name he gives to the silk. With the increase of wealth and luxury in the Grecian Court, the demand for silks augmented prodigiously. The Persians for a time engrossed the trade of Greece, and became rich from the commerce of silk, which they procured from China. The ancient Phœnicians also engaged in the traffic of silk, and carried it to the east of Europe, although in ignorance of the country whence their supply was drawn. From Greece it passed into Rome, and though the exact year of its introduction is unknown, it was probably about the time of Pompey and Julius Cæsar, the latter we find having used it in his festivals. The demand for silken articles rapidly increased under the Emperors, in spite of all prohibitions and restraints, and so great was the drain of specie from the Eastern Empire on account of silk and other Eastern productions, that the Emperor Justinian resolved to introduce the cultivation of silkworms into Europe; and encouraged by his promises and gifts, two Persian monks succeeded, about A.D. 550, in carrying the eggs of these insects to Constantinople. The Greeks soon acquired great skill in the production of raw silk, and carried on its manufacture at Thebes, Corinth and Argos, and other places in the Peloponnesus, undoubtedly deriving

their designs from the cotton and linen, if not silk looms of Al Modayn, Alexandria, Tabriz, Damascus, Tyre, and Antioch. The manufacture was subsequently carried by the Saracens from Baghdad, Tabriz, Aleppo, and Alexandria into Sicily, and examples are extant of the Saracenic silks of Sicily of the 12th century. Roger, King of Sicily, also carried a large number of silk manufactures from Greece to Palermo, in A.D. 1147. In another hundred years the manufacture of silk had extended to Lucca, and thence, about sixty years later, to Venice, Florence, Milan, Genoa, and Bologna. The manufacture of silk goods was brought from Lucca to Lyons, probably as early as the 15th century, but it made little progress until the silk culture and the production of the cocoons and raw silks, were established at the beginning of the 17th century. In England the manufacture had made a little progress in the 15th and 16th century, but all attempts at silk culture had failed. In Austria, Germany, Switzerland, and the Low Countries there were manufactories of silk, but very little silk was grown.

The decline of the pre-eminence in the manufacture acquired thus early in Italy has been more than counterbalanced by great success in the cultivation of the mulberry, the diffusion and multiplication of the silkworm, and, in consequence, the enormous abundance of the silk which is annually collected. Thus, if the preparation of the tissues have suffered in certain localities, where the art was formerly very active, as a compensation the silk operations have been carried out upon a scale which all the countries in Europe combined together cannot equal.

A general approximate view of the yield of cocoons and of the production of raw silk in Italy for the years 1875 and 1876, may be obtained from the following table, drawn up by the Syndicate of the Union of Lyons Silk Merchants:—

	Yield of 1875.		Yield of 1876.	
	Cocoons.	Raw Silk.	Cocoons.	Raw Silk.
	Kilos.	Kilos.	Kilos.	Kilos.
Piedmont, Liguria, and Sardinia	6,200,000	414,000	2,100,000	140,000
Lombardy	15,000,000	1,000,000	4,300,000	287,000
Parma and Piacenza, Reggio (Emilia) Modena, Massa-Carrara	1,020,000	71,000	642,000	45,000
Romagna	520,000	35,000	247,000	16,000
Marche and Umbria	780,000	56,000	636,000	47,000
Tuscany	1,600,000	130,000	812,000	65,000
Neapolitan Provinces, Calabria and Sicily	2,320,000	165,000	1,540,000	110,000
Venetia and Friuli	10,700,000	650,000	3,560,000	237,000
Tyrol (Austrian and Italian)	1,270,000	85,000	700,000	46,000
Total	39,410,000	2,606,000	14,537,000	993,000

Thus the yield of cocoons in 1876 was not quite 37 per cent. of that of 1875, the yield in raw silk being 38 per cent. of that of the previous year. In 1877 the yield of cocoons was calculated at 22,450,000 kilos, or one-third more than in 1876. The yield of raw silk, according to the figures compiled by the Cavaliere Pasquale de Vecchi, and published by the *Sole* newspaper for the same year, was 1,853,400 kilos. These returns are considered thus far reassuring, since they are greatly in excess of the previous year, 1876, although they only show one-half of the ordinary harvest previous to the disease in the worm.

The Syndicate of the Lyons Merchants have, likewise, published a table showing the production of raw silk in Europe and the Levant, together with the exports from China, Japan, and India, during the years 1874, 1875, and 1876:—

	Raw Silk.		
	1874.	1875.	1876.
	Kilos.	Kilos.	Kilos.
France	731,000	731,000	155,000
Corsica and Algiers	—	1,100	1,150
Italy	2,860,000	2,606,000	993,000
Spain	131,600	115,100	85,500
Portugal	—	3,600	3,000
	3,722,600	3,456,800	1,237,650
The Levant:—			
Turkey-Anatolia (Broussa)	206,000	152,000	105,000
„ Volo	37,000	22,800	15,700
„ Salonica	63,000	56,900	42,000
„ Adrianople	63,000	51,000	36,000
Syria	170,700	135,700	117,500
Greece	13,000	16,000	16,000
Georgia, Persia, Khorassan	400,000	310,000	310,000
	952,700	744,400	642,200
*The Far East:—			
China—Exports from Shanghai	3,373,200	3,297,400	3,525,000
„ „ „ Canton	824,100	1,011,300	1,020,800
Japan „ „ Yokohama.	597,000	679,000	1,150,000
East Indies Exports from Calcutta	604,200	386,400	564,800
	5,398,500	5,374,100	6,260,600
General Total	10,073,800	9,575,300	8,140,450

* Including the exports to America and India.

The quantity of silkworms' eggs or grain imported into Italy, according to the Customs Returns for 1877, as compared with 1876 and 1875, was as follows:—

	Quantity.	Value.
	Kilos.	Italian Lire.
1875	74,140	22,242,000
1876	47,790	19,116,000
1877	126,034	15,117,000

The exports for the same years were:—

	Quantity.	Value.
	Kilos.	Italian Lire.
1875	9,105	1,821,000
1876	10,290	2,881,200
1877	8,968	1,076,160

The quantity of cocoons of all kinds imported and exported during the same period is noted below:—

	Imports.	
	Quantity.	Value.
	Quintals.	Italian Lire.
1875	11,436	14,866,800
1876	11,378	22,756,000
1877	8,425	11,795,000

	Exports.	
	Quantity.	Value.
	Quintals.	Italian Lire.
1875	12,943	19,414,500
1876	9,770	22,432,000
1877	6,641	11,258,200

The silkworm is reared principally by the peasantry in their own dwellings, and the cocoons are either sold direct to the proprietors of the filatures, or are disposed of at the country markets; in fact, a regular traffic exists in the article. This is apparent from the frequency of carts laden with the cocoon sacks that may be seen passing along the roads in the silk districts. The worm is described as being very voracious, allowing the peasant no rest at the period of its incubation, as the supply of the mulberry leaves requires to be constant and unfailing. There are, however, large silk-breeding establishments, and I am indebted to Vice-Consul Kelly for a description of an establishment belonging to Signor Susani, at Albiate, in the Brianza. On rising ground, in the midst of his own estate, in a charming country, not far from the picturesque banks of the Lambro', Signor Susani, a gentleman of independent fortune, has arranged his Cascena "Pasteur," not in one block, but in scattered buildings, according to the modern hospital system, to avoid the spread of infectious diseases. Great attention is paid to warming, ventilation, and cleanliness, but all arrangements are made for practical use without any attempt at outward show. It was in the midst of the breeding season when our visit was paid, and we found Signor Susani busily engaged in inspecting some dead worms, and noting down in a special register the cause of death, and the date of their decease. We were most cordially received, and visited in detail the whole establishment. The worms are carefully attended to by bright-looking peasant girls, who feed, change the beds of, and watch over their charges with the most careful solicitude.

To prepare cellular grain for the market, three years are required. The first year each couple of moths being placed in a coarse muslin bag, are carefully examined under a microscope after depositing their eggs; if no germs of disease are discovered their eggs are reared the second year, the product of every pair in a separate division, so that their characteristics can be thoroughly studied. In a register, or regular stud book, all particulars of birth, existence, and death are noted, each family under its numbers. The moths from these worms, after coupling and depositing their eggs, are also examined under the microscope, and the third year their grain is reared in two or three healthy sets of eggs together, the same care as before being taken in their registration. The grain produced from these worms, if all has gone well, is ready for sale for the following season. The qualities of silkworms to which Signor Susani pays the greatest attention are the yellow Brianza breed and Japanese reproductions.

Two qualities of grain are produced at Albiate, the "cellular" and the "commercial," the latter being prepared with less care than the first. The prices fixed for the season of 1878 were as follows:—

	Per ounce of 25 grammes. lire c. lire c.
Cellular grain:—	
Japanese reproductions	11·70 to 16·00
Italian (Brianza)	19·00 to 21·00
Commercial grain:—	
Japanese reproductions	8·00 to 9·00
Italian (Brianza)	12·00 to 15·00

or even at lower rates, according to the quantity purchased.

There are three interesting epochs for a visit to Albiate during the breeding season, when the moths couple, and during their examination under the microscope. The amount of work to be got through may be surmised from the fact that at the busiest season, though only for a short time, 1,000 women are sometimes employed.

The difference, as I am informed by a silk grower, between the "commercial" and "cellular" grain, consists in that the first is prepared in the ordinary manner, after a number of microscopic observations of moths, proving that the whole number, or the greater portion, are without corpuscules. For example, from a bulk of 1,000 kilos. of worms, from which it is intended to obtain eggs, take off at hazard 200 or 300 cocoons, then hasten the coming forth of the moths by warming, and examine one by one their blood under the microscope. If it is found that all such are free from corpuscules, it may be concluded of the bulk that 90 per cent. are good, 70 per cent. middling, and less than 50 per cent. bad. The "cellular" system consists in separating each couple of moths, male and female, in order to obtain as many deposits of eggs as there are couples. Each couple is afterwards examined by the microscope, and if the inspection proves their healthy condition, the corresponding deposits are adjudged good, and if on the contrary they are rejected. Many persons think it sufficient to examine the female, whilst others believe the inspection of both sexes indispensable.

The complaint amongst the silkworms at the period of its greatest intensity caused much distress amongst the peasantry, who depend much upon the vine and the mulberry. The Indian corn, or *grano turco*, as it is called, is the daily food in the form of polenta, whilst the fig tree furnishes the dessert. There is a peculiar system called the "mezzadria" which exists in the province of Bergamo, the northern province of Como, and almost universally throughout Tuscany. This is a contract between the owner of the soil and the peasant, by which the first gives a habitable house, suitable for farm uses, with a certain quantity of land, not only under proper cultivation, but planted with mulberry trees and vines, the latter with their props. The peasant contributes his labour, and also the working capital in seed, farm implements, and cattle. The produce of the soil is divided into equal shares between the two parties. For the house and meadowland the rent is paid in money, and though the immediate products of the soil are shared equally between the peasant and proprietor, special stipulations often regulate the division of the grapes and the mulberry leaves, the latter the most important product of the territory. In the northern province of Como, and the northern part of Milan, as I am informed, there is a stipulation by which the produce of the soil is wholly given to the tenant, for which a fixed rent is paid in corn, called *fitto a frumento*, and the cocoons and other products grown in plantations, *i.e.* mulberries, vines, &c., are shared between the proprietor and the peasant. Where the silk industry prevails the women are seldom employed in field labour, the silk mills finding them employment; and during winter, when there is no out-door occupation, they spin the flax grown on their small farms. The houses of the peasantry in general are poor but not squalid, since the breeding of the silkworm necessitates their being built of a certain size, and tolerably well ventilated. The country people are decently clad, the men in fustian and cotton velvet, the women in cotton prints.

The mulberry tree appears to have formed an object of cultivation at a very early period in the western parts of Asia and in Europe. The attention there bestowed upon it must have been solely on account of its fruit, for the knowledge of the mode of rearing silkworms was confined to the people of Central and Southern Asia until the sixth century. The white mulberry, *morus alba*, is considered both in Italy and France by far the best variety for cultivation as food for the silkworms. It is a tree of much more rapid growth than *M. nigra*, and its leaves are not only less rough and more succulent, but they contain more of the glutinous milky substance resembling caoutchouc, which gives tenacity to the silk produced by the worms fed on them. When the silkworm was first introduced into the north of Europe there appears little doubt but that it was fed on the leaves of the black mulberry. The white mulberry is more tender, and putting forth its leaves much earlier than the black mulberry, it is

more likely to be injured by spring frosts. It was, consequently, long confined to Greece; but when Roger, King of Sicily, in 1130 ravaged the Peloponnesus, he compelled the principal artificers in silk and breeders of silkworms to remove with them to Palermo, and determined to try the white mulberry in that country. The white mulberry was accordingly transplanted into Sicily, and flourishing in its fine climate, that island became the great mart of nearly all the raw silks required for the manufacturers of Europe. In 1440, the white mulberry was introduced into Upper Italy, and in the reign of Charles VII. the first white mulberry tree was planted in France.

According to Count Dandolo a hundred trees, great and small, will furnish 7,000 lbs. of leaves, and these will be sufficient for 200,000 silkworms. The greatest care should be taken, whatever may be the quality of the leaf, to prevent its being heated or fermented, whether just picked or when kept. The leaves ought not to remain long in the baskets or sacks in which they are gathered. The mulberry tree thrives in colder countries than Lombardy; the leaves are gathered in May, when the tree is in full vegetatiou, and when the silkworms are feeding vigorously, but it should ouly be stripped once a year, and that crop should be gathered, so as to allow time for the leaves to shoot again before the cold weather. Many peasants have a custom of gathering the leaves in the autumn for the feeding of cattle, which is condemned by all good horticulturists, since the mulberry tree suffers from this practice, as well as from the conditiou of the weather. About five-sixths of the raw silk is converted into organzine and tram, which increases its value about 30 per cent. The factories in which this work is carried on, especially the principal ones, are fitted up in the most perfect manner, and conducted upon the most approved principles. A great number of the works are dispersed over different localities, adapted for the purpose, either by the cheapness of labour, proximity to waterworks or waterfalls to set in motiou the machinery, for the facilities with which fuel can be obtained, or abundance of cocoons in the neighbourhood. The mills for making the organzine (*filatoz orsoj*) are not so numerous as those for spinning. The principal spinning mills work five or six months in the year, and those of lesser importance from four to six months only. The organzine mills are nearly always at work.

The period of activity with the silkworm occurs in the month of May. The eggs are about the size of mustard seeds, and the larvæ of the first age are one or two lines long, and of a dark colour. In five days begins the second stage. In the third stage the worm is naked, whitish, and lives six days before attaining the fourth. The fifth stage is the longest, lasting nine days, aud at this time the worm is very voracious. It theu ceases to eat, walks about, and, in about 36 days after the worm hatches, it begius to make its cocoou, which is spun from the large sized glands opeuing in the under lip. The cocoon is spun of a continuous thread about 1,000 yards long, and is finished in about four days. The cocoons vary in colour; the white, two varieties of yellow, and the green. There is a considerable difference in weight, according to the races, the conditions of atmosphere in which the silkworms have been reared, their feeding, &c. The white and green Japanese cocoons are generally lighter than the white and yellow Italian races. Thus 600-1,000 white or green Japan cocoons weigh one kilog, 400-700 white or yellow Italian cocoons weigh one kilog. The cocoons intended for seed, *i.e.*, for the hatching out of the silk moth, are first selected with care, and the remainder are subjected to some one of the several processes for destroying the life of the chrysalis, as, otherwise, the moth would force its way out through the cocoon and spoil it for reeling. The cocoons, which are then called dry cocoons, are next assorted, those as nearly of a size as possible being put together, aud the largest by themselves. The small cocoons are much less valuable, and the *dupions*, or double cocoons, are generally rejected, as there is difficulty in reeling them. All soft or imperfect cocoons are also rejected. When thus assorted they are ready for reeling. The floss or coarse loose silk is taken off, and the cocoons put, eight or ten at once, in a kettle or a pan of quite warm but not boiling water, and stirred with a bit of broom, or a whisk, lightly and gently till the silk fibre is loosened and can be caught up. A fibre from each cocoon is then passed through the holes of the brass plate which covers the pan or kettle, and then repeatedly crossed and carried forward to the reel. The reeling process requires great skill to keep the thread even, as the amount of silk in each cocoon varies, and it is constantly necessary to be joining new threads. The threads are also of different degrees of fineness on different portions of the same cocoon. The threads thus united in the reel form what is known as raw silk.

Raw silk, before it can be used in weaving, is made to take one of three forms, being converted into either singles, tram, or organzine. The first, which is the most simple process, consists of merely twisting the raw silk, in order to give more firmness to its texture; in fact, during its progress towards the formation of the two other preparations, raw silk must pass through the intermediate state of singles. Tram is formed by twisting together, not very closely, two or more threads of raw silk, and this description most commonly forms the weft, or shoot, of manufactured goods. The formation of organzine is a more elaborate performance, and is principally used in the warp, that is, to form the length of the goods. Through the courtesy of one of the partners of the well-known firm of Signor Pietro Gavazzi, Via Cusani, Milan, I was enabled to examine the different processes, from the unwinding of the cocoon to the weighing and packing of the silk, carried on in their filature at Valmadrera, near Lecco. This establishment has long been most favourably situated in a locality possessed of many natural advantages. It contains every requisite for the storing of the cocoons, and has a numerous *clientele*, the result of the indefatigable efforts of the partners for perfecting every branch of the busiuess. At the time of my visit the different operatious were proceeding in rooms spacious and well-ventilated, each containing about 20 persons, who carefully watch and guide the threads of silk as they traverse the machines, the whole of the machinery being propelled by water power. The health, comfort, and cleanliness of these *employés* is au object of coustant solicitude to the firm, siuce much of the success in the fabrication of the article depends upon the intelligence aud care bestowed upon it by the persous thus employed.

The Casse di Risparmio of Lombardy, oue of the wealthiest aud most prosperous of the institutions of the country, which has its head office in recently erected and spacious buildings in the Via Monte di Pieta, at Milan, is largely useful to the merchants engaged in the silk trade. It is a common practice for such to deposit their bales of silk aud cocoons and receive advances thereon. Visitiug this fine establishment in compauy with Vice-Consul Kelly, we were euabled to observe minutely every variety of cocoou, their colours, sizes, shapes, &c., and the modes of packiug that distinguish the products of different silk-growing countries. The statistics of the Casse show that during the year 1877 the quantity of silk deposited in their hands amounted to 631,359 kilogs., valued at 27,054,000 lire, and the sum advanced was 9,897,435 lire, iuterest being at the rate of 5 per cent. The funds at the disposal of the Casse are very considerable; on the 31st December, 1877, the capital of the establishment consisted of 25,600,340 lire, and the amounts lying in its hands belonging to depositors came to 253,350,000 lire additional.

The manufacture of silk fabrics, although dwarfed in importance when compared with the production of the

raw material, is carried on to a considerable extent in the different towns and districts. The principal silk goods manufactured are plain broad silks, black and coloured, failles, taffetas, satins, and in a less proportion figured silks, velvets, scarves, ribbons, parasol and umbrella silks, silk hose, silks for furniture, silks for churches, and ecclesiastical vestments. The principal towns in districts employed in the trade are—Como, with about 6,500 looms, almost exclusively employed in the manufacture of plain silk for dresses. Milan, with about 1,000 looms employed in the manufacture of plain silks, figured silks, silks for furniture, silks for churches, silks for ecclesiastical vestments, umbrella and parasol silks, cravats, scarves, ribbons, and silk hose, &c., and about 100 looms employed in the manufacture of velvet. Turin, with about 500 looms for the manufacture of a variety of silk goods. Genoa (Riviera), with about 1,000 looms employed in the manufacture of velvets. Naples (S. Leucio) with about 500 looms for various silk goods. Rome, with about 100 looms for various silk goods. Catania, with about 1,000 looms for plain silk goods. Lucca, with about 800 looms for plain silk. Florence, with about 1,000 looms for plain silk goods. The total number of looms is about 20,000. With regard to the proportionate extent of steam, water power, or hand-looms employed, I have been informed by the same authority that there are about 500 steam or water power looms, and the remainder are hand-looms. These steam or, more generally, water power looms are situated at Menaggio, Cernobbio, Desio, and Chiari; the looms of Desio, belonging to the firm of E. P. Gavazzi, are employed in the manafacture of umbrella silks. The hand-loom weaving is carried on both in the town and country districts. Of the 6,500 looms in the city and province of Como, two-thirds may be said to work in the suburb and country district, whilst at Milan the hand-loom work is almost exclusively confined to the city. At Turin there is one hand-loom weaving establishment. At Milan there are five, the most important belonging to the well-known firm of Ambrogio Osnago. At Naples (S. Leucio) there is one. The hand-loom weaving is, however, chiefly carried on by the workmen in their own dwellings. At Como, of the 9,000 silk weavers, 6-10ths are men and boys, 4-10ths women and girls. The average rate of earnings for the men upon figured silk goods is from 2fr. to 3fr. 50c. per day, and upon plain silk goods, from 1fr. 50c. to 2fr. 50c. per day. The average rate of earnings for the women is 1fr. 25c. a day of twelve hours; the rate for girls varying from 50c. to 80c. a day. The exportation of silk tissues during the year 1877 has notably declined upon former years, whilst the imports have increased, showing that although Italy possesses *par excellence* the raw material, she makes purchases from abroad of the manufactured article.

The attacks of the silkworm disease have occasioned many important changes during several years past, more especially in the larger use of Chinese and other Asiatic silks, the facilities for obtaining which have been greatly extended by the opening of the Suez Canal. The effects of this scourge vary in a remarkable manner, according to the time of the attack, the intensity of the disease, and a number of other circumstances. Wherever the disease appeared, recourse was had to seed from a distant place, taking as much care as possible that it should be brought from some part which had not been attacked by the disease. It results that, in Italy, and in some provinces more than others, the cocoons produced of late years have been of all sorts, all shapes, and of every quality; and in spite of the best directed efforts, made with a view to obtain a satisfactory production, as well in point of quality as quantity, it must be admitted that the crop of silk since the commencement of the disease has been diminished to one half of what it was in ordinary years. Many looms, and especially the smaller, have remained idle, and the larger have been kept on short time. The manufacturers, especially in Upper Italy, have modified their machinery, so as to increase their business by working the Chinese and Levantine silks. Notwithstanding that silk weaving has suffered more than any other trade, the Italians have not despaired; on the contrary, they have given proof of great intelligence, zeal, and activity, in endeavouring to mitigate the effects of this calamity. They have not neglected the cultivation of their mulberry trees, and they have instituted examinations by the microscope, and experiments, with a view to secure good cocoons in greater abundance than the normal production of recent years. If any convincing proof were needed of the ability of Italians to contend with the difficulties inseparable from commerce, this might be found in their treatment of the silkworm.

The statistics of the exports of raw and thrown silk show that in spite of the diminished production within the country, a larger quantity has been exported abroad. The opening of the eastern sources of supply has naturally led to larger importations to fill up the vacuum, and this prominent feature in the trade renders it important to improve the dock and storage accommodation at the ports of Venice, Brindisi, and Genoa. It is, moreover, desirable to quicken the period of transit by the Mont Cenis railway, which by passenger trains only occupies twenty-two hours between Turin and Paris, whereas for goods traffic many days are now consumed. The importance of the early completion of the St. Gothard route cannot be overlooked, since the connection between Switzerland, Germany, Austria, and Italy, is at present hindered by the difficulties of transport. The Italian filatures use a very considerable quantity of China, Japan, and Bengal silks, which are highly appreciated by the consumers. The Asiatic silks are introduced direct from China, besides being obtained at Lyons, Marseilles, and London. By far the greater portion of the production of the Italian silk mills is purchased by the merchants of Lyons, and worked into the splendid fabrics for which that city has always been famous. The largest consumers, next to Lyons, are found amongst the manufacturers of Switzerland and the Rhenish Provinces. The remainder is distributed between the different European silk markets, viz., England, Austria, Saxony, Russia—the smallest quantity being woven in Italy herself.

The falling off in the demand for silk of all kinds which occurred during the year 1877 must be regarded as quite exceptional, owing to the general depression of commerce throughout Europe, for in such case silk, an *article de luxe*, would be amongst the first to feel its effects. It may, however, be reasonably anticipated that with the return of peace and prosperity, this great industry of Northern Italy, upon which so much ability and attention has been concentrated, may again expand into larger dimensions than it has ever yet assumed.

CAPABILITIES OF ALGERIA AS A WINE-PRODUCING COUNTRY.

Consul-General Playfair, having visited many of the most important vineyards in the three provinces of Algeria, and placed himself in communication with the most experienced viticulturists, desires to offer a few observations to such of his countrymen as have already purchased land in the colony, and who may entertain the idea of planting part of it with vines. Monsieur Dejernon, professor of agriculture in the Basses-Pyrenées, who, at the instigation of the Governor-General, was sent on a mission by the Minister of Agriculture to study this important question on the spot, thus states his general impressions regarding it:—

"In my eyes, the vine is a providential plant for Algeria; it prospers everywhere—in the worst land, in the most burning soil; I have not found a spot which is unfit for it. Everywhere also, but especially in the

littoral, I have tasted wine, rich in alcohol, which would have had precious qualities if only it had been better made, and from other plants. The vine will become the fortune of the country. . . . . Algeria possesses in its geological structure, in the rays of its sun, in the currents of its air, in its topographical details, those precious qualities which give to the products of the vine their tone, their colour, their delicacy, and limpidity. It can produce an infinite variety of wines, suited to every constitution, and to every caprice of taste."

Although Mons. Dejernon is of opinion that there is no part of Algeria unfit for the culture of the vine, there will probably always be a great difference, both as regards quality and cost of production, between the wine grown on the plains and that produced in the more mountainous part of the country, such as the Sahel of Algiers. In the former, the original planting can be done in deeply-ploughed furrows, and the subsequent culture by means of ploughs of a lighter description, therefore expeditiously and cheaply. In the latter, where the ground is hilly, and the land generally in small holdings, all these operations must be done by hand, and this necessitates a great expenditure both of time and money. On the other hand, the wine of the plain will probably always be of an inferior quality, though more remunerative as a mere commercial speculation. The difference in the price of wine made in the Sahel and in the plain will usually be from 15 to 25 per cent. in favour of the former.

We are still groping in the dark, and there are only two points proved beyond the possibility of doubt—that Algeria is admirably suited for the production of wine, and that hitherto very little science has been displayed in the production of it.

The most important plain is that of the Metidja, which every traveller passes through on his way by train to Blidah. This is formed by alluvium and detritus, washed down from the first slopes of the Atlas Mountains, which the opposite heights of the Sahel have prevented from being carried by winter torrents to the sea; this, for the most part rests on an argillaceous sub-soil, so that the water absorbed by the ground at the foot of the mountain percolates through it at no great distance from the surface, keeping the soil moist and fresh, and finally, in the lower parts of the plain, bursts forth in abundant springs, or is reached by artesian wells of no great depth. The soil here varies to a great degree, but a considerable portion of it consists of small stones and pebbles mixed with pure alluvium; a soil easily permeable both to rain and air, and of all others the best adapted for the vine. One farm rented by Consul-General Playfair, belonging to M. Laroque, was not in an exceptionally good position. 45 hectares, or 112 acres, were planted with vines, not altogether in full bearing. During the past season the owner made 1,600 bordelaises (double hectolitres), or 70,000 imperial gallons of wine, which he expected to sell for 55 francs the bordelaise. The net product would be 73,000 francs; in other words, every acre of land in the estate under cultivation with vines produced an actual revenue of £26. The wine was not of very good quality, but it had a ready sale, and one cannot doubt that by the application of a little more care and science in the selection of the plants, the planting of the vines, and the manufacture of the wine, its quality would be greatly improved.

The chief value of the vine, in a country which suffers so much from periodical draughts as Algeria does, is that it seems to flourish as well in the dryest years as those in which the rainfall is copious. This last season—one of the driest within recollection—all throughout the plain of the Chelif the crops failed entirely, and even in the Metidja they were far below the average; yet with crops burnt upon the ground, there was a brilliant patch of verdure round every village caused by the vines, and the vintage was fairly abundant. A small vineyard, therefore, is the colonist's best insurance; it must, indeed, be an unfortunate year when both wines and cereals fail. The principal cause of failure up to the present time appears to be that the French vine grower, coming to Algeria, cultivates and prunes his vines as his fathers have done for ages before him in his native village in France. He has not realised that with change of place every condition of viticulture has changed—the climate and soil are different; there, after the pruning of his vines, the young shoots are liable to be nipped by frost; in Algeria, the planter sighs for spring rains to swell his grapes, and the greatest enemy he has to contend against is the serocco wind, which is liable to kill the fruit, and which modifies every condition of fermentation to which he has been accustomed. The most successful wine-growers are those who have had no previous experience elsewhere, and who have only attained to success in Algeria by repeated failures. Unquestionably the best vines have been grown by two Englishmen and a Frenchman who had passed a good deal of his life in the United States, where he never saw a vineyard. One of the former, Mr. Holmes, gained the gold medal at the Agricultural Exhibition of 1875; the others, Mr. Ledgard and M. Grellet, produce wine which is known to, and appreciated by, every English visitor to Algiers.

The quantity of land planted with vines throughout the whole of Algeria in 1877 was 19,674 hectares, which produced 222,424 hectolitres of wine. The province of Oran is that in which it has been most cultivated; it produced 93,173 hectolitres of the amount given above; the province of Algiers came next, and Constantine is beginning to augment its production.

PATENTS IN GERMANY.

The patents granted by the German Patent-office since its opening on the 1st July, 1877, to the 29th of October, 1878, attain a total of 3,635. They may be divided in 89 classes: preparations, 17; bakery, 13; clothing industry, 19; objects for lighting, 72; mining, 50; beer and brandy, 69; products of tin and wire, 33; bleaching, dyeing, printing on stuffs, and furnishing, 100; manufacture of brittle goods, 9; fuel, 19; book-binding, 32; chemical apparatus, 35; steam boilers, 84; steam engines, 103; printing, 44; preparing manure, 5; preparing ice, 15; preparing iron, 34; railways, 75; working of railways, 171; electrical apparatus, 30; substances for dyeing, 27; fat industry, 6; fuel establishments, 46; engines for twisting, 32; preparing gas, 41; blast-engines, 19; tanning, 13; fabrics for spinning, 20; sanitary arrangements, 50; casting, 15; glass, 21; hand and implements, 46; house-heating implements, 173; lifting tools, 19; arrangements for heating, 68; systems of building, 58; wood, 40; horn, 11; science of smelting, 10; hat manufacture, 10, instruments for measuring, observations, and so forth, 174; basket making, 1; hardware, 80; agricultural implements, 84; air and gas pressure engines, 36; engine elements, 115; chemical metal-working, 2; mechanical metal-working, 121; mills, 71; musical instruments, 44; sewing machines, 53; alimentation, 20; paper productions, 32; paper manufacture, 13; harness, 23; presses, 16; pumps, 60; regulators, 17; life-saving apparatus, 15; salines, 3; saddlery, 28; implements for tap-houses, 90; shipbuilding, 22; butchery, 30; grinding, 13; locks, 68; cutting instruments, 19; writing and drawing materials, 34; shoes, 37; fire-arms, 56; rope making, 1; systems of signalling, 9; soda, 29; spinning, 54; sport, games, &c., 39; explosive substances, 15; tobacco, 16; earthenware, 53; transport systems, 8; arrangements for drying, 31; watches, 30; waterworks, 3; water conductors, 55; weaving, 48; implements, 65; wind and water pressure engines, 25; and sugar and starch manufacture, 37.—*Trade Marks.*

TECHNICAL SCHOOLS AND COLLEGES FOR BUILDERS IN PRUSSIA.

The first technical school for builders founded in Prussia was opened about twenty-five years ago at Nienburg-on-the-Weser, in the then kingdom, now the Prussian province, of Hanover. It early became a Government establishment, and for a long time remained the only institution of the kind, but within the last ten years a number of similar schools have been founded, generally by private persons. These institutions have, however, generally passed into the hands of local authorities, and now the central government has given notice wherever such schools exist that it is prepared on certain conditions to make annual grants for their support. The conditions are that the State shall have the right of co-operating in the general organisation of the institutions, in laying out the course of instruction, in the appointment of the teachers, and in the holding of examinations. These institutions are quite distinct from the ordinary trade schools which have been in operation in Prussia for a long period. For the latter, a comparatively high entrance examination has to be passed, and a regular three years' course of instruction, including the higher branches of theory and practice of the chief trades and some of the professions, is given to all students attending them. The new technical school for persons entering the building trades, on the other hand, only requires in the pupils as much education as is imparted in the common elementary schools, together with some experience in actual building work. The course extends over a year and a half to two years, and the time devoted to the classes, which include drawing, planning, mensuration, taking out quantities, estimates, practical demonstrations in work, the knowledge of all processes, instruments and materials used in the trade, occupied no less than 48 hours a week, or eight hours a day. The western provinces of Germany are already tolerably well supplied with this class of schools, the chief being those at Holzminde and the fine *Bauschule* at Hamburg. In the eastern provinces, on the other hand, there is such a dearth that Prussian subjects have been compelled to avail themselves of the building schools of Saxony, and it is accordingly intended to establish a number of new institutions in suitable centres in that portion of the country. In addition to this reorganisation of the building schools, the Government is creating new technical schools for other special trades in several of the chief seats of manufactures. Thus in Crefeld, a great centre of the cotton and silk manufactures, the old School of Weaving, which has fallen into neglect, is to be remodelled under the combined auspices of the Government, the Town Council, and the Chamber of Commerce, and is to be turned into a school of textile industry, worthy of the present times. At Iserlohn, again, which is one of the chief centres of the cutlery and metallic industry, the old provincial trade school is to be entirely reorganised, and turned into a great technical college for all branches of metallic industry.

All this is only part of a grand scheme of reorganisation of the various classes of technical schools in Prussia. Thus the Bauakademie, or central Building College of Berlin, is to be united with the *Gewerbe Akademie*, or central Trade College of that city, so as to form one great central Technical College, which is to be placed under the laws peculiar to universities in Germany. All the other trade schools (*Gewerbe Schulen*) of the kingdom are to be divided into two groups. Another innovation which it is proposed to introduce without delay is the establishment of technical workshops and laboratories in connection with all the middle and lower trade schools, in which certain improvements suggested by a recent inspection of similar institutions in France, Austria, and South Germany, are to be embodied. It may be also noted that on State railways workshops are to be erected specially for the teaching and training of young men in all branches of the technical and scientific, as well as the practical, work of railway engineering.—*Builder*.

ON THE UTILISATION OF THE AFRICAN ELEPHANT.

Sir Joseph Fayrer recently wrote as follows to *Nature* on this subject :—

The *Colonies and India* contained a short but suggestive article under the heading "Notes," "Elephants in Cape Colony," which deserves consideration. It states that elephants are numerous in the interior of Cape Colony as well as in Central Africa, yet no one seems to have attempted to catch and tame them. The subject has already been mooted that there is a good field for their use, both in Central Africa and in Cape Colony, and that they would prove a new and important method of opening up and utilising the wealth of the Colony, and of furthering the explorations in Central Africa, which are now of such general interest.

It appears that a troop of wild elephants has been observed within 50 miles of Port Elizabeth; on these the attempt might first be made; and it is well known that they abound in Central Africa, where, indiscriminately slaughtered for the sake of their ivory, the destruction of these animals is so great, as at no very distant period to threaten their extinction. It seems worthy of consideration whether it would not be better to attempt to utilise them as beasts of burden, as is done in India, where they are of inestimable service to the Commissariat, the Public Works Department, the planters, and many others. The African differs from the Asiatic elephant in some points, but is equally well adapted for labour; and, there can be no doubt, would be as easily tamed and trained as is his Indian congener. That this is the case is amply proved by the docile and submissive state into which the male and female African elephants now in the Regent's-park Gardens have been brought by Mr. Bartlett and their keeper, Scott. They appear to be just as obedient, intelligent, and free from vice as Indian elephants; and there is, I think, little doubt that the one species, under proper training and discipline, would be as useful in Africa as the other is in India.

There is every reason now to hope that the wealth and resources of our South African possessions will undergo development; might it not be well to revive the suggestion that the elephant should be enlisted in the good work? The importation of one or more of the numerous officers who have been trained to the work of catching and domesticating wild elephants in India, with a fitting establishment, and, perhaps, a few Indian elephants to commence the work, would very soon put the value of the undertaking to the test, and probably show that a vast source of working power now unused might be made available.

It is probable that, in ancient times, the African elephant was domesticated, and any one who has studied the two magnificent specimens in the Society's collection in Regent's-park, will, I think, be satisfied that they may again be so, and that, in temper, docility, and working power, they would be equal, if not superior, to the Indian elephant.

Through the medium of the columns of *Nature*, perhaps an impetus may be given to a matter that is certainly worthy of consideration, and may elicit further remarks from some of the Indian Keddah officers, who are practically experienced in the mode of dealing with elephants. It is, at all events, worthy of Sir Bartle Frere's consideration.

CORRESPONDENCE.

THE CULTIVATION AND CROPPING OF BAMBOO.

My attention has been directed to an error in my comments on Mr. Thomson's report (which appeared in last week's *Journal*) in stating the average rainfall at Calcutta as 50 inches instead of 80 inches.

The fact, however, remains that in all hot countries, especially where the rainfall is scant and variable, the value of irrigation has from time immemorial been recognised, and cultivation, wherever practicable, carried on under this system. In Egypt, Spain, Peru, and elsewhere, the sugar-cane, which is, botanically, closely allied to bamboo, can only be grown under irrigation.

Where growing indigenously, the bamboo, indeed, only commences to throw up its ordinary seasons's shoots at the beginning of the rains, and, quoting from the observations of Dr. Ribbenthrop (Conservator of Forests, British Burma), "there can be little doubt that by artificially irrigated plantations we can force the productivo power of bamboo stocks to a very great extent." THOMAS ROUTLEDGE.

Claxheugh, Sunderland,
7th January, 1879.

GENERAL NOTES.

Mr. J. T. Taylor.—A farewell dinner, with the presentation of a testimonial, was given on Saturday last, to Mr. J. T. Taylor, on his retirement from the editorship of "The Journal of Photography," a post which he has occupied for many years, with acknowledged advantage to the progress of the art. Mr. Taylor has, it is understood, accepted a position in the United States, which promises a successful future. Mr. Taylor has at times been a contributor to the *Journal of the Society of Arts*. He leaves England in a few days, taking with him the good wishes and esteem of all who know him. The dinner was well attended by all the principal photographers, who heartily wished him God speed in his new undertaking. The testimonial consisted of a Benson's chronograph, and a purse of gold, in all to the value of £200.

Lancashire Sewage Scheme.—The *Times* of 23rd December reports that a conference of local authorities, engineers, and others interested in tho economical disposal of water-carried sewage was held at Manchester on Friday last, the 20th inst., at the invitation of Sir Henry Cole, K.C.B., to discuss a proposal for bringing the smaller towns of Lancashire into local federations for the purification of their sewage. The meeting was attended by representatives of a considerable number of districts. Sir Henry pointed out in some detail the advantages of the proposed federal system, the adoption of which was calculated to save at least one-third the expense of the treatment of sewage. The idea was generally approved by the other speakers at the conference, but some of them anticipated much difficulty in persuading different localities to adopt combined action as proposed. A resolution commending the principle to the careful consideration of sanitary boards was passed, and on the suggestion of Sir H. Cole, the meeting was adjourned for three months, with a view to practical steps being devised in the meantime. It is stated that there are nearly a hundred places, having about 5,000 persons, the greater number of which could make a profitable union by combined action.

Australian Sugar.—Sugar-planting in Australia, says the *British Trade Journal*, is attaining considerable importance. Mr. Newcombe, Government Statist for New South Wales, reports that the gross quantity manufactured in the statistical year 1877-78 amounted to 150,744 lbs. against 93,960 lbs. in the previous year—or an increase of 60 per cent. This result is very gratifying, as an indication that the industry is remunerative and is likely to take an important position in the colony. Not only in New South Wales, but in Queensland, in the North Territory of South Australia, and in West Australia, all of which are favoured with a climate and soil even better adapted than those of the older colony for sugar-planting, large tracts of land are already devoted to the cultivation of the cane, and every year sees an addition to the capital invested and to the area under the crop. In Queensland, for instance, about 25,000 acres are planted with sugar cane, the produce of which is very nearly 16,000 tons of sugar a year.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at Eight o'clock. :—

JANUARY 15.—"Economy and Safety, by the Use of Automatic Couplings, on Railways." By T. A. BROCKELBANK, Esq. F. J. BRAMWELL, Esq., F.R.S., will preside.

JANUARY 22.—"The Modern Science of Economics." By HENRY DUNNING MACLEOD, Esq., Barrister-at-Law.

JANUARY 29.—"The Distribution of Disease popularly considered." By ALFRED HAVILAND, Esq., M.R.C.S.E.

FEBRUARY 5.—"The Best Methods for Improving the Condition of the Blind." By Dr. T. R. ARMITAGE.

FEBRUARY 12.—"The Application of the Bessemer Process to the Reduction of Metallic Sulphides." By JOHN HOLLWAY, Esq.

FEBRUARY 19.—"Turkey and its Resources." By J. L. HADDAN, Esq.

FEBRUARY 26.—"Indian Pottery at the Paris Exhibition." By GEORGE BIRDWOOD, Esq., M.D., C.S.I.

MARCH 5.—"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By JOSEPH J. POPE, Esq., M.R.C.S., L.S.A.

MARCH 12.—"The Compensation of Time-keepers." By EDWARD RIGG, Esq., M.A.

MARCH 19.—"Economical Gardens for Londoners." By W. MATTIEU WILLIAMS, Esq., F.R.A.S., F.C.S.

MARCH 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor BARFF, M.A.

CHEMICAL SECTION.

Thursday Evenings, at Eight o'clock.

JANUARY 30.—"Gas Illumination." By Dr. WM. WALLACE, F.R.S.E.

INDIAN SECTION.

Friday Evenings, at Eight o'clock.

JANUARY 17. — "Affghanistan." By C. E. D. BLACK, Esq. Col. H. YULE, C.B., R.E., will preside.

January 31.—"Quest and Early European Settlement of India." By George Birdwood, Esq., M.D., C.S.I.

February 21.—"The Trade of Central Asia." By Trelawney Saunders, Esq.

March 7.—"The Moral and Material Progress of India." By H. Phillips, Esq.

African Section.

Tuesday Evenings, at Eight o'clock.

January 21.—"Retrospect and Prospect in Egypt." By B. Francis Cobb, Esq.

February 4.—The Opening of the District to the North of Lake Nyassa, with Notes of a Recent Expedition through that Country." By H. B. Cotterell, Esq.

March 18.—"Some Remarks upon an Old Map of Africa contained in Janson's Atlas, published at Paris in 1612." Communicated and exhibited by R. Ward, Esq.

April 1.—"The Contact of Civilisation and Barbarism in Africa, past and present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

Cantor Lectures.

Monday Evenings, at Eight o'clock. First Course, on "Mathematical Instruments." Six Lectures, by Mr. W. Mattieu Williams.

Lecture V.—January 20, 1879.

Instruments for Measuring Mass.—The scale beam—The steel yard—The spring balance—Laboratory balances—Cavendish's torsion balance for weighing the earth—Weighing the earth by plumb-line—Weighing the earth by pendulum. *Instruments for Measuring Short Intervals of Time and Great Velocities.*—Wheatstone's and Foucault's mirrors—The chronograph—The spectroscope as applied to the measurement of velocities.

Lecture VI.—January 27, 1879.

Instruments for Recording or Representing Results of Mathematical Processes.—Plotting and Drawing Instruments.

These lectures will not be addressed to mathematicians, but the subject will be treated in simple and elementary forms; any technical term that must necessarily be used will be explained when introduced.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Household Sanitary Arrangements." It will consist of Six Lectures, to be given on the following dates:—

February 17, 24, March 3, 10, 17, 24.

The Third Course will be by Mr. W. H. Preece, on "Recent Advances in Telegraphy." It will consist of Five Lectures, to be given on the following dates:—

April 21, 28, May 5, 12, 19.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon.....Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. 1. Mr. J. Thomson, "A Journey Through Cyprus in the Autumn of 1878." 2. Mr. Edwd. Hutchinson, "Recent Information from Victoria Nyanza."
British Architects, 9, Conduit-street, W., 8 p.m. 1. Resumed Discussion on Captain Burton's paper, "Remains of Buildings in Midian." 2. Mr. Thomas Verity, "The Modern Restaurant."
Medical, 11, Chandos-street, W., 8.30 p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. E. B. Tylor, "Good and Bad Etymology."

Tues....Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture I.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. 1. Discussion on "Railway Work in Japan." 2. "The Best Means of Developing New Countries by Railways."
Photographic, 5a, Pall-mall East, S.W., 8 p.m. 1. Capt. Abney, "The Emulsion Process." 2. Colonel Stuart Wortley, "An Instantaneous Shutter."
Zoological, 11, Hanover-square, W., 4 p.m. 1. Mr. A. D. Bartlett, "The Habits and Changes of Plumage of Humboldt's Penguin." 2. Dr. Morrison Watson and Dr. Alfred H. Young, "The Anatomy of *Hyæna crocuta*." 3. Dr. O. Finsch, "A Collection of Birds made by Mr. Huebner, on Duke of York Island and New Britain."
Royal Horticultural, South Kensington, S.W., 1 p.m.

Wed....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. T. A. Brockelbank, "Economy and Safety by the Use of Automatic Couplings on Railways."
Meteorological, 25, Great George-street, S.W., 7 p.m. Annual Meeting. Address by President. Presentation of Testimonial to Mr. Symons.
Entomological, 11, Chandos-street, W., 7 p.m. Annual Meeting.
Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. Thomas Morgan, "The Roman Army in North Britain with reference to Recent Discoveries." 2. Mr. C. Roach Smith, "Roman Fictile Statuettes from the Allier." 3. Mr. W. C. Little, "The Roman Road between Denver and Peterborough."
Society of Public Analysts, Burlington-house, Piccadilly, 5 p.m. Annual Meeting. 1. Mr. O. Hehner, "The Determination of Phosphoric Acid as Phospho-molybdate." 2. Mr. E. W. T. Jones, "The Influence of the Decomposition in Butters from age on the Specific Gravity of the Fat and the percentage of Soluble and Insoluble Acids."

Thur....Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W., 8 p.m. Mr. J. G. Baker, "The Colchicaceæ and Aberrant Tribes of Liliaceæ."
Chemical, Burlington-house, W., 8 p.m.
London Institution, Finsbury-circus, E.C., 7 p.m. Prof. Rolleston, "Man's Power of Modifying External Nature."
Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. H. Gordon, "Electric Induction." (Lecture I.)
Institution of Mechanical Engineers, 25, Great George-street, S.W., 11 a.m. Annual Meeting. 1. Captain C. O. Brown, R.A., "The Construction of Armour to resist Shot and Shell." 2. Mr. H. Allason Fletcher, "The Heslop Engine, a Chapter in the History of the Steam Engine." 3. Captain Douglas Galton, "The Effect of Brakes upon Railway Trains." (Third Paper.) 4. Mr. R. Price Williams, "On the Cost of Working Railway Traffic."
Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

Fri......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. C. E. D. Black, "Afghanistan."
Institution of Mechanical Engineers, 25, Great George-street, S.W., 11 a.m. (As above. Papers and Discussions continued.)
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting; 9 p.m. Prof. Tyndall, "The Electric Light."
Philological, University College, W.C., 8 p.m.
Quekett Microscopical Club, University College, W.C., 8 p.m

Sat......Royal Institution, Albemarle-street, W., 3 p.m. Prof. Seeley, "Reptilian Life." (Lecture I.)

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FRIDAY, JANUARY 17, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

SWINEY PRIZE.

The adjudicators under the will of the late Dr. Swiney are summoned to meet on Monday, the 20th January, 1879, at the Rooms of the Society, at 12 o'clock, to make the award in conformity with the terms of the bequest contained in the will of the testator.—By order,

16th Jan., 1879. P. LE NEVE FOSTER, Sec.

JUVENILE LECTURES.

The second and concluding lecture of the two Juvenile Lectures was delivered by Mr. W. R. S. Ralston on Friday evening, the 10th inst., on the "Mythology of Fairy Tales."

AFRICAN COMMITTEE.

A meeting of this Committee was held on Wednesday last, the 15th inst. Present—Colonel HARLEY, C.B., C.M.G., in the chair; Rev. G. P. Badger, LL.D., Mr. J. Bergtheil, Mr. B. Francis Cobb, Mr. E. Hutchinson, and Mr. F. Swanzy, with Dr. Mann, Secretary to the African Section.

TEACHERS OF MUSIC IN ELEMENTARY SCHOOLS.

The committee of the Manchester Branch of the Lancashire Association for Promoting the Cultivation of Music among all, report to the Society of Arts that ten free scholarships for teachers of elementary schools have been awarded by competition at Owens College. Mr. Hecht, the Professor of Harmony and Composition at Owens College, states that the examination was in a knowledge of notes, keys, and time, as well as in voice and ear, that eight scholarships were obtained by schoolmasters of elementary schools, one by a teacher of music, aged 17, and one by a warehouseman, aged 20. Among the competitors were four clerks and one "warper," &c., and the rest of the twenty-three candidates were schoolmasters or assistants. Two not appointed were specially recommended for additional scholarships. Mr. Hecht states that the general proficiency of most of the candidates was most satisfactory, such indeed as to qualify them to teach elementary music. This fact has strengthened his opinion that, notwithstanding the frequent assertions to the contrary, the English people are really musical, and he is prepared to say that had he assembled for examination, under similar conditions, an equal number of schoolmasters from any continental nation, he would not have found so large a proportion with good voices, and an equally high standard of general proficiency in music.

This is the first local examination for elementary teachers, which is intended to lead to the establishment of schools of music in places which have already classes for art and science, and to the discovery of young persons of great musical ability and promise, who may be sent to the National Training School for Music, originated by the Society of Arts.

SIXTH ORDINARY MEETING.

Wednesday, January 15th, 1879; Lord ALFRED S. CHURCHILL, Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Barron, William Adamson, Althorpe-house, Queen's-road, Richmond-hill, Surrey.
Begbie, Robert S., Stafford-lodge, St. Mary's-terrace, Paddington, W.
Benjamin, Eugene, 169, New Bond-street, W.
Cook, Edward C., 208, Oxford-street, W.
Halliday, William, 4, Northampton-terrace, Harrow-on-the-hill.
Lewis, John, 7, Harley-place, Regent's-park, N.W.
Logan, William George, 9, Adelphi-terrace, W.C.
Neill, John, M.A., Greenock.
Nolloth, Admiral Matthew Stainton, A 12, Albany, W.
Parker, Walter M., Alton, Hants.
Read, Richard John Gifford, 15, Flora-villas, Albion-gardens, Hammersmith, W.
Saunders, Captain A. J., R.A., Gatestone, Central-hill, Upper Norwood, S.E.
Spalding, Frederick George, Lennox-house, Manor-way, Blackheath, S.E.
Verne, Amadie, La Société Indienne de l'Electricité, 29, Rue Taitbout, Paris.
Weir, William, 38, South Audley-street, W.
White, Thomas John, Amana-lodge, 140, Tulse-hill, S.W.

The following candidates were balloted for and duly elected members of the Society:—

Atkin, Frederick, Mortomley, near Sheffield.
Flower, Frank, 3, Piccadilly, W.
Meyer, M. R., 16, Mark-lane, E.C.
Miller, David, Beachley, near Chepstow.
Orange, William, M.D., Broadmoor, Wokingham, Berkshire.
Reid, James, Hyde-park Locomotive Works, Glasgow.
Vernon, Thomas, C.E., Tonedale-villa, Cheltenham.
Webber, William Downes, J. P. Mitchelstown Castle, Co. Cork.

The paper read was—

ECONOMY AND SAFETY FROM THE USE OF AUTOMATIC COUPLINGS ON RAILWAYS.

By T. Attwood Brockelbank.

Few of those who have watched the extension or development of railways, in any part of the world, will be inclined to dispute the fact that railways, in themselves, in their work, and in their results to the community, are revolutionary. From their commencement and throughout their career in this country, of now but half a century, the change in and around them has been increasing, and, as we all admit, the end is not yet.

It is when contemplating this evolution, which has brought us step by step from the old coach bodies of the stage coach type, run on rails, up to the palatial drawing-room and sleeping cars, now an accustomed sight on our main lines, that the far-reaching extent of the continued progress is forced upon our notice, nor do we even then wholly realise its significance, until we examine in detail and consider how the many component parts of these vehicles have also participated in this evolution.

From the locomotive, that panting mass of mechanism on wheels, down even to the wheel tyres of the lowly luggage trolly, evidence is presented that well-nigh every item has improved in shape or texture, weight or fastening, and the manufacture itself of these parts, which, at first making, was accomplished by slow and laborious process, is now, in almost every detail, aided or completed, by the giant power of steam, with a speed and completeness that is simply marvellous, there being hardly a part, either in the rolling stock or permanent way of a railway, which has not been either wrought, or punched, or grooved, slotted, or drilled, or planed by machinery, until to the community at large, and alike to rich and poor, have been secured luxuries and advantages such as were only dreamt of at the earlier stages of railway progress—advantages which we are in the habit of accepting with no thought, but as necessities of the time.

Such a review, hasty and inadequate though it must be, surely constrains us in passing to bear our testimony to the intense labour and expenditure of mechanical skill, energy, and perseverance by which these have been attained, and to yield our meed of praise to those under whose responsible direction this great advance has in the past been secured.

One exception, however, and about the only exception in the whole range of railway detail to partake of this universal improvement, is the manner and method of connection and disconnection of vehicles which continues, in this country and on the continent of Europe, as slow, clumsy, and stupid in practice, and is worked in as barbarous, dangerous, and fatal a fashion, in this year of grace 1879, as it was half a century ago.

The truth of this, no one who ever visits any of the large goods yards scattered over this country will contest for a moment; but I trust my condemnation of the method will not be held to imply censure on existing railway management. The rapid extensien of railways all over this land has had much to do with hesitation in this matter, and shelved this reform in favour of others of more urgent nature.

Amongst the principal obstacles to this reform, the independent and often antagonistic action in the formation of railroads has been an important item; again, the making of branch lines for the purpose of feeding main lines, the subsequent transfer of them to the larger undertakings, and the consequent necessity of working the most miscellaneous rolling stock intermingled, have one and all tended to keep in abeyance any decisive attempt to deal with the acknowledged inconveniences and dangers of the present system. Until overborne by the more pressing requirements, this improvement, except where it is distrustingly viewed as a mere humanitarian device, has faded so far out of the range of official vision, that its introduction, which would, in the earlier stages of railway working, have been secured and carried through with little difficulty, and, moreover, have saved the railway companies literally millions of money, now confronts us under much more onerous conditions—conditions which a reference to our Table (column A) acquaints us, are progressing with rapid strides, for, as we there learn, the wagon stock of these ten companies has increased 50 per cent. between 1870 and 1878.

It is now five years since I brought to the notice of railway companies certain mechanical means devised to save life and to reduce accidents, in the dangerous work of coupling and uncoupling vehicles. As may be anticipated, it obtained from the various companies very different receptions; but one point was universally admitted, viz., that the necessity for an effective improvement of the character designed existed on every railway, the urgency for which is only bounded by the extent and nature of its traffic. Officials in various undertakings were ready to welcome such a result, but they were unanimously of opinion that, unless a pecuniary advantage could be secured to railways, or at least no pecuniary loss result therefrom, it would be vain to expect railway companies to adopt any such improvement, however mechanically successful or beneficial from a humanitarian point of view, or without such alteration being enforced by legislation. Search for opportunity to develop my views, under great discouragement, convinced me that, however good foundation these pecuniary objections seemed to pessess to those who advanced them, there was, in the adoption of automatic couplings, that very consideration of economy and money advantages the companies themselves required. Not only did it appear to me that they are not avoiding the expenditure they dread, but that they are actually rejecting, in automatic couplings, that which will preserve them, in economical working, a source of dividend for shareholders; and investigation into the working of railways has satisfied me that a most important acceleration of traffic, and a very large

monetary saving, will result from the general use of automatic couplings on England's railways in place of the present system of entire manual labour. In fact, it would be contrary to all experience of the results of the introduction of mechanical operations in place of manual were this not so.

I shall now endeavour to use this opportunity, so kindly given me by your Council, to lay before you the conclusions I have arrived at by mechanical experiments and examination, and by sifting the returns of railway traffic, assured that the far-reaching importance of the subject will gain me a patient hearing, especially when it is borne in mind, both by the speaker and his audience, that there is bound up in this alteration increased immunity from accident, alike to the passengers and the servants on railways.

Just now I mentioned mechanical experiment, and for this reason, that I desire you to believe that, in the remarks which I may make, I am speaking as one who is acquainted somewhat fully with this branch of the subject; but as it is wholly beside my purpose to enter upon any description of inventions or their working, or to touch upon the question of the mechanical feasibility of any proposed idea, it becomes necessary that I should ask you to agree with me fully in one article of faith, viz., that the eminent engineering and mechanical ability which has so successfully grappled with nearly every other detail on railways will not fail in supplying this want, when once automatic railway couplings present themselves to railway management as a paying investment.

Coupling reform has, in the past, been looked upon principally as a question of safety to *employés*, or at most as a goods traffic requirement; and if we limit ourselves to the contemplation of it only as regards the connecting facilities it affords, it certainly does not promise much increased safety to passengers; but it is in this very aspect that the importance of it will first make itself felt, and this I hope to prove as we go along.

Having, therefore, considered together the almost universal improvement which has attended on railway enterprise, and after having taken notice of this coupling want, as yet unsupplied, and glanced at some of the various obstacles which beset the path of this reform, we have now convinced ourselves that pecuniary considerations must largely influence its adoption on railways. Let us now proceed to deal with the figures provided for us to digest.

It is of course necessary in such a paper as this that we should limit our examination to the salient points of our subject. Nor could we well deal with numerous details which, in their bearing, are perhaps of equal importance with those selected. All we can do is to endeavour to arrive at an approximate conclusion; to go beyond this would land us in a mass of intricate calculations. We should have to consider, amongst many other things, waste in steam in goods engines, to check and allow for the usual locomotive charges, calculate savings in coal, reduction in wear and tear, estimate demurrage expenses, consider overtime of goods guards, engine drivers, stokers, and shunters, perhaps of signalmen and inspectors; in fact, it would be necessary, having first obtained our data, to investigate the working of most matters treated of in the haulage of trains and general despatch of traffic. The area is so large, the sources are so numerous, and the channels so many, through which railways savings filter and economies bear fruit, that I must content myself with the endeavour to show that railway directors and management, railway shareholders and passengers, and the entire rank and file of railway officials, as also the mercantile community, are very deeply interested in a satisfactory solution of the problem—will the substitution of automatic couplings upon English railways pay?

TABLE OF PARTICULARS UPON TEN OF THE PRINCIPAL RAILWAYS IN ENGLAND AND SCOTLAND.

A.	B.	C.	D.			E.	F.	G.	H.
Goods' trains mileage. one year.	One year's service of goods' trains.	Coupling operations.	Authorised engine load.		RAILWAY.	Wagons. 1870.	Wagons. 1878.	Increase. 1870-78.	Average life of wagons.
Millions.	Thousands.	Millions.	Loaded.	Empty.					
$6\frac{1}{4}$	440	33	45	58	North Eastern	62,154	74,231	12,077	10
$8\frac{1}{4}$	850	65	40	50	London and North Western	29,993	42,682	12,689	10
$3\frac{1}{4}$	260	22	45	50	Caledonian	16,399	41,432	25,033	$13\frac{1}{2}$
$6\frac{3}{4}$	800	60	45	55	Great Western	18,972	33,160	14,188	$12\frac{1}{2}$
$7\frac{3}{4}$	650	52	38	48	Midland	18,367	31,244	12,877	$12\frac{3}{4}$
$2\frac{1}{4}$	300	22	45	50	North British	16,319	25,286	8,967	$10\frac{1}{2}$
$3\frac{1}{4}$	350	26	45	50	Lancashire and Yorkshire	14,414	18,513	4,099	$11\frac{1}{2}$
$1\frac{3}{4}$	250	20	40	50	Great Northern	10,441	15,319	4,878	$11\frac{1}{2}$
2	220	17	50	55	Great Eastern	9,546	11,034	1,488	$11\frac{1}{4}$
	100	8	45	50	Manchester, Sheffield, & Lincolnshire	7,323	10,851	3,528	10
90,250,000	4,220,000	325				203,928	303,752	99,824	

NOTE.—The increase in Goods Train Mileage between 1870 and 1878 was 30 per cent.

One word as to the figures in this table. As an outsider, unconnected with any railway, I have no special sources of information open to me beyond such public and general reports as are available to most of us. Faultless figures I do not profess to provide from such materials, but this I can assert, that my totals do not err in exaggeration, but are well within the facts of the case.

We have here then a table of certain particulars, upon ten of the principal railways of England and Scotland. Column A gives us the mileage reported by these companies as run by goods trains

during one year, a total of 44 millions of miles. I am unable to find out whether this is the number of miles actually covered by these trains, or which would have been traversed had the trains been going during the times they respectively occupied on their journeys; but be this as it may, the total is so large that it is difficult to grasp its immense importance. Column B provides one year's service of goods trains as running over the respective lines, and of this column I would only say this, if any railway official who has particulars at his command, which I lack, should judge the traffic over his railway to be over-stated, I shall be glad to receive authoritative correction in the course of this month, such correction to be founded on actual traffic worked in 1874-5-6. Column C is the key to our subject, from which, for the moment, we will pass to column D. This presents us with the wagon load allotted to engines on these lines—an important factor, as we shall see—but as I have myself seen an engine start on a journey of 100 miles with 59 vehicles on one of these railways, whose maximum is 50, we may judge that maximum is not a hard and fast line. Columns E and F place us in a position to judge of the rapid increase of wagon stock owned by these companies during the past eight years, which column G shows us to be nearly 50 per cent. increase on 1870. Column H supplies us with the average life of wagons on these several lines, by which we are in a position to estimate that, in addition to the increase of 99,824 wagons, these companies have, in the aggregate, replaced no less than 135,152 of their old stock, or a total renewal and additional increase of 234,976, or nearly five-sixths of their whole present wagon stock in eight years.

If any of us experience (and few have not) the hopelessness of an attempt to catch up a half-hour lost in the earlier part of a busy day, we get some idea of what occurs when the start of a goods train from any point is later than its working time-table fixture; we can hail cabs and race to and fro from appointment to appointment, often to find the day gone and our intended work half done. With a goods train behind time all traffic is adrift. Passenger trains which should have passed it half way on its journey shut it up in a siding when but about a third of the journey has been passed, and other trains, of which it ought to see nothing, crowd it out of the way, time after time, along the route, until it often occurs that double the time it is booked for has been expended in the journey. For, be it borne in mind, the expediting of a train means, far more often than not, all the difference between long detention or getting clear away, between completing the task in a reasonable time, or incurring heavy overtime charges. Passengers, no less than officials, appreciate the importance of punctuality; delay at one point is repeated farther on, until, if we could look back along the route, we should behold an amount of congestion and disorganisation of traffic sufficient, in the case of goods trains, to lead to daily and hourly disasters, were not the subordinate work on railways so conscientiously and zealously performed as it usually is. We who, as passengers, entrust our lives to the care of officials, should never forget that, while in a vague sort of way we recognise delay in shunting as a fruitful source of calamity to ourselves or our fellows, it often presents itself to the official, after he has done all he can to prevent it, in the form of loss of livelihood and loss of character, or in the more terrible form of trial and conviction for manslaughter.

Column C gives us, with trains of 25 vehicles, 325 millions of couplings operations, to deal with, and we have here a very large field for speculation. Now, we will assign but ten seconds per operation as the difference in favour of automatic couplings, as compared with the present manual labour, by which we obtain from these seconds' saving alone no less a period than 100 years (night and day) clear to the traffic superintendents, in twelve months' working, for the despatch of other traffic. In this total the actual working of these particular journeys only are included; no estimate can be given of the many millions of other coupling operations which are effected continuously day and night at such large centres of traffic as Birmingham, Bristol, Glasgow, Liverpool, Manchester, Newcastle, Nottingham, Peterborough, or Swansea, in the intermediate manipulation of trains; nor of the work accomplished in London goods yards, the vast extent of which must be seen to be believed, such as Paddington, Bricklayers' Arms, St. Pancras, Maiden-lane, Willesden, or Poplar, in all of which, apart from actual train formation for a journey, multitudinous operations are executed which would be facilitated by such an improvement. For be it remembered also that these 325 millions of operations in our column are calculated at but three per vehicle; every wagon of a train must at least be coupled up and recoupled at one end; in numerous cases both operations occur more than once on a journey. This yields us 75 operations from start to destination. Is this all? By no means; no account is taken in this total of pick-up trains. These journey from station to siding, and from siding to station, transferring from place to place as many as 200 vehicles in the journey, the engine executing various shunting operations on the way, necessitating 500, 600, or at times 1,000 distinct coupling operations, with a pick-up and shunting engine on a long journey.

Yet, again, it is an every-day occurrence for an engine driver to be told by the official in charge of the siding, or goods yard from which he is booked, that he has been so long in getting the train made up that he cannot get through for at least half an hour; and, if need were, instances could be given where a delay of two minutes has entailed a four hours' wait at one spot on a train journey.

It may tend to give us some idea of the enormous traffic that unceasingly goes on about our immediate neighbourhood, when we learn that in London district and suburban trains there is daily an interchange of traffic between the companies representing traffic at no less than 350 stations, goods yards, and junctions, and sidings. Of these from 70 to 80 are goods yards and cattle stations.

In the United Kingdom there were, during 1878, as near as possible, 13,000 stations, junctions, sidings, and collieries working. If one minute per day only be saved in them by automatic couplings, the work would be accelerated by a period of time in the course of every year repre-

sented by no less than 3,295 days, or nine years.

With regard to the mileage run by goods trains in the United Kingdom, the increase in the total between 1870 and 1878 for these ten railways has been 30 per cent., and this despite the fact that 1878 is less than 1877.

So much for time-saving. Just a word as to collisions contributed by delays in shunting.

It may be naturally concluded that if two passenger trains collide, the results are more terrible than when a passenger train comes into collision with a goods train, or part of one. This conclusion, however, is hardly borne out by facts; in the latter case, where passengers and goods trains meet, the damage to rolling stock and to permanent way is usually much more destructive, and the deaths among the passengers much more numerous. Statistics are easily procurable for any one who desires to satisfy himself of this. But could passengers possibly have more potent reasons for bidding a welcome to an improvement conducing to punctuality of goods traffic, than that it would largely tend to reduce chance collisions?

What avoidable detention now involves it is impossible to imagine, but this we do know, that some goods trains only succeed in reaching their destination on the day following that appointed for their arrival—in some instances 24 hours behind time.

The block system on railways has proved of great value; increased safety to passengers is unquestionably obtained by it, but it is not an unmixed good, and it is possible that those much-burdened beings, traffic managers, might reveal something of an obstructive character about it; they only can tell us how many enforced stoppages now occur where a never-ending chain of trains (in dangerous proximity it is true) once worked off the traffic into its various channels unlet by home and distance signals; but this is certain, the punctual despatch of traffic is, if possible, of greater importance under the block system than before, especially for goods trains, which do not possess that advantage which passenger trains usually have, viz., a certain marginal facility for making up lost time.

It is not, of course, within my province to allude to the merits of the grievous struggle now going on between employer and employed; but we may discern in this time-saving and punctuality a panacea to some extent in the vexed question of the trip system; for if I judge rightly, it is this terribly unequal working which galls, and this with improved punctuality would be robbed of half of its terrors.

However sceptical railway men may be as to the realisation of this saving of time upon the adoption of automatic couplings, this they must admit, that they don't see any other way to secure it, and they will heartily join in the opinion that it a consummation devoutly to be wished.

We now pass on to money saving. A writer in "Fraser's Magazine," of September, 1877, treating of goods traffic as an obstacle to reduction of passenger fares, continues thus:—"The mineral traffic opposes first a physical and then a financial obstacle to the multiplication of third-class trains; it literally stops the way. It financially consumes so much of the profit earned by the conveyance of passengers, that it leaves no margin for the reduction of fares."

Here is a writer arguing, as it seems he does, with a full acquaintance of his subject, that if we can expedite out of the way the offending goods trains, and aid them to pay their own way, we shall place it in the power of the railway companies to reduce passenger fares, and herein I am entitled to enlist the warm sympathies of passengers in my effort to convert officials to my views.

Railway accounts are not easy of digestion, even to those whose accustomed food they are, and judging by my own attempts to understand them, I come to the conclusion that it is perfectly impossible to arrive at reliable comparison of the working expenditure of goods traffic on the large railways, so various are the modes of reckoning.

In a leading article of the *Railway News* of the 23rd March, 1878, it is stated that "All attempts to form a reliable comparison as to the economical condition of the different railway companies from the returns presented by the lines are futile, so long as each company makes up its train mileage according as fancy or caprice may direct." And from the same article we learn that with one company if a train is delayed standing in steam for two hours, its journey, which on the time bills represented 160 miles, would be returned at 200 miles, although 160 miles had only been travelled. Again, "Some companies, it would appear, include in the train mileage reported the work done by engines shunting. Consequently extraordinary discrepancies exist in the accounts."

If this writer, who has means of information far beyond my reach, finds himself unable to interpret the returns, it is self-evident that for us a complete digest is hopeless, and that we must content ourselves with generalities.

The difference of one penny per train mile on our traffic in the United Kingdom amounts to about a million sterling per annum, and of one per cent. in the proportion of expenditure to receipts, to about £600,000, so that there would be an enormous addition to the net earnings of the companies if this only can be secured; and I have reason to believe not only this sum but a very much larger total annually can be economised.

Let it be borne in mind that, apart from the time-saving, which must in itself prove of large pecuniary value, the increased despatch which brings a train to the end of its journey sooner has saved the cost of unburnt coals, as also a certain amount of engine wear and tear, it has either reduced demurrage charge on all wagons, or brought those wagons earlier on the demurrage list, placing them in a condition to earn more profit each per annum. The excess time wages of men, drivers, stokers, and goods guards, are also either saved for the time, or the men set free for other duties. Did time permit, we could enumerate a multitude of economies, unnoticeable except in the aggregate, in which this despatch bears fruit; in fact, so important is despatch, that when a train is shut up in a siding waiting to get along, it is only a shade less costly than if it were actually running its journey; indeed it is sometimes the case that five journeys out of ten a train occupies double as long on its journey as its time-table allows it, and its increased working charges exceed thirty per cent. of its proper cost, being of course so much less

to the company which runs it, and a hindrance, expense, and source of danger to those foreign lines over which it runs.

These companies on our lists are, *de facto*, the great carrying companies of the United Kingdom —in every respect they rule the trade—and upon them would fall the brunt of such a reform.

If we put the saving at an average of but one shilling per journey, the result to them, in economy of working, apart from time advantage and reduction in chance of collision, would amount to a quarter of a million a year, an average of £25,000 per annum each, sufficient to pay 10 per cent. on the outside amount of capital possible to be required for the supply of automatic coupling apparatus to their own wagon stock, and if there ever was a period during the last twenty years favourable to such an alteration, brought about by the condition of trade, it is the present—with labour and materials at their lowest, and with traffic checked in its onward annual increase. At present the companies can face and execute a reform that is inevitable, under advantages the like of which may—nay, will—never occur again.

We have, so far as we have gone, considered reduction in working expenditure, but there is more especially another saving, contingent upon the adoption of improved couplings—it is a portion of our subject much canvassed outside railways. I refer, of course, to the continuous loss of life and the constant and terrible injuries, which day by day occur on railways, and which, judging by the steady totals which year by year are returned, appear inseparable from the present mode of conducting railway traffic. This state of things is a constant drain on the purses and efficiency of the companies, to say nothing of the loss which always befalls all commercial enterprise when suddenly deprived of capable and faithful servants.

I have no wish to-night to stir up by sensational statements antagonistic opinions upon a subject about which much may be said, but I cannot pass over the fact that, between 1870 and 1878, some 4,000 passengers were killed or injured from collisions between passengers and goods trains, or parts of goods trains. This total is apart and distinct from those resulting from collisions occurring between two passenger trains. Nor must I omit that, within that same period of eight years, 7,000 servants succumbed to accidents in and about shunting operations.

The cost to the railway companies for accidents of various kinds was, in round numbers, as follows:—For the passengers they have had to pay between two and three millions sterling, by way of compensation; about two millions sterling more was paid for goods—this item, I would remark, is not wholly compensation for accidents by collision. Something like a million more was spent on replacement and renewal of damaged rolling stock and permanent way; and how much more the companies lost respectively in frightened passenger traffic, in consequence of collisions, there is no means of ascertaining, but the total must be large.

Compensation to servants is not the law of the land, but, unless the signs of the times are very misleading, we shall not compass another period of eight years without its enactment in some shape or form, sufficient to make a material increase in the totals annually payable by the companies. Be this as it may, we must be all agreed that the terrible nature and frequency of accidents, both to passengers and servants, constitutes a great claim for attention, and that, weighted as it is with this enormous money expenditure, it supplies a very strong argument for urging upon those in authority a deep and earnest attention to the proposition which we have been considering together.

Of course, any one who advances such a theory as that automatic couplings will pay, must anticipate a shoal of objections and adverse criticism. Look, says one, at the enormous number of vehicles working in England. Look, says another, at the cost of alteration to the companies. Think, urges a third, of what you have to encounter.

I am quite willing to discuss with any one these various points, but I have no time to work out the question in this evening's paper; I must be content to say—that there never yet has been a reform of any magnitude which has not had first to run the gauntlet of its detractors, and then to live down their objectors.

The cost of alteration is a bugbear which, by the side of the outlay on the block system, or the outlay in the matter even of brakes, is, in proportion to the savings to be obtained, very small indeed, and is an item of account which, if railway management could realise the advantages within its grasp, would not hinder their realisation another year longer.

As to the time necessary to carry the alteration out by fitting an apparatus to new wagons only, column II supplies us with the average lives of wagons on these lines, by which we may conclude that the fitting automatic couplings on wagons brought to workshops for repairs, and the supply on new wagon stock so fitted, would complete there form with no special pressure in less than ten years; for, be it remarked, that these companies who keep their rolling stock in the front class of working order, have in eight years' time renewed, on the average, two-thirds of their stock of 1870, apart and distinct from their additions; and we may fairly conclude that nearly every one of the remaining third have come in for repairs during that term.

I submit, therefore, that I have presented to your consideration a proposition well worthy of the careful investigation of railway managers and shareholders, and one which affects the lives and pockets of the public, as passengers, and the lives and limbs of the servants. I contend, moreover, that I have shown a reasonable prospect of dividend to be economised thereby in railway working.

This question in all its varied aspects is not one that can be settled by private individuals; the companies have a giant monopoly, which is unfavourable either to independent or joint action. Hitherto efforts to secure safety to those engaged in the hazardous duty of connecting vehicles has been the most prominent object put forward by those advocating this reform, such efforts being chiefly left to the initiative, and labours, and cost of private persons, fostered and aided in some cases by humane and earnest-minded officials; but any serious attempt on the part of the railway companies to work out or ascertain for themselves, either in the interests of their pockets or of humanity, whether automatic couplings could be

obtained or would pay, has been wholly wanting; but it is a great satisfaction to be able to discern a growing sense not only of the monetary value of such an invention, but also of the sacred duty which is incumbent on those in authority, and are morally responsible, to save life. Each attempt in the past, fruitless, hopeless, or despairing, as it may have appeared to the discouraged inventor, has yet done its part in educating officials and the public, and to the growth of the conviction that, come early or late, the reform is inevitable. Much has been done, and is yet being done, by outsiders; but surely this is not a position which should be held by the railway companies of England, the pioneers, be it remembered, of railway enterprise and railway improvements throughout the world.

It has been well said by an eminent writer, that "he who steps out of the crowd is listened to with suspicion and heedlessness." William Gray, the engineer, was so disgusted with the apathy of his fellows at their inability to perceive the great merits of the tramways he advocated, that he left recorded of them, upon the fly-leaf of his prayer-book, "Eyes have they but they see not, ears have they but they hear not." The biographical works of Mr. Samuel Smiles have shown us what others had to encounter of like character, and it is in our own knowledge how the American, George Train, fared when he tried to establish tram-cars in our midst, and how that which we then rejected with contumely we are now employing, not only throughout the metropolis, as a chief means of intercommunication, but in every important town in the kingdom.

Yet one more. A Sheffield manufacturer, who, 20 years ago, advocated the adoption of steel rails in lieu of iron, with such enthusiastic energy that the engineers of Great George-street suggested that his relatives should put him in a lunatic asylum, but a few short months since was presented with a testimonial to his perseverance, and an address of congratulation for this very energy.

To those not to be convinced by the arguments and figures presented, I would say that, in this which is so eminently a practical matter, I claim to have established my case until the day when in actual working automatic couplings fail to pay. Of the necessity for this alteration there can be no question.

To its urgency every quarterly return, with its records of fatal injuries received in and about the perilous duty, testifies, and now, to all who listen, the immense time, saving, and great money value which attaches to its realisation are proclaimed in this paper.

DISCUSSION.

Mr. Liggins said this was a subject of vast importance to the community at large, particularly to the railway interest, for he believed that want of punctuality in trains was the fertile cause of most of the catastrophes which occurred. He had no interest in railways, except a share here and there, but he had reason to believe that railway directors were overwhelmed by applications from inventors, and in such a multitude they found it very difficult to select, which would, perhaps, account for no action being taken by the great railway companies. They were much indebted to Mr. Brockelbank for the thorough investigation he had given to the subject, which would open the eyes of the public and of the railway world, and he hoped the scientific portion of it would urge upon their directors the adoption of some such system as had been referred to.

Mr. Ashbury thought one great obstacle to the introduction of an automatic system of couplings was the interchange of traffic; but the fact that it had been adopted on many colonial lines, and by foreign railways, showed that it was a necessity according to the ideas of modern engineers. In Norway, Sweden, some parts of India, Brazil, and many of the colonies, this system was much used, and he had expected to have heard how it had succeeded there. No doubt if it could be shown to have succeeded where it had been tried, it would be a great encouragement to its adoption.

The Chairman said he had hoped there would have been some gentlemen present connected with the railway interest, who would have taken part in the discussion. They were much indebted to Mr. Brockelbank for his instructive paper, and especially for the valuable and curious statistics he had given. There could be no doubt there would be a great economy both of money and human life, if an automatic system of couplings were adopted. Mr. Brockelbank had told them that a saving of 10 seconds on each coupling was equivalent to a saving of a hundred years in time on the ten principal railways in the kingdom; and this would represent a large economy of money. The great difficulty was to get railway companies to take the initiative. He understood that the Great Eastern had made some experiments which proved successful, and perhaps Mr. Brockelbank would state presently what they were. Possibly one difficulty in the way was the question whether the system could be gradually introduced and worked conjointly with the old, because it would evidently be impossible to have the whole of the rolling stock altered simultaneously. He was assured, however, that this could be done, and had been done in the experiments on the Great Eastern Railway, and, if so, this was a practical illustration of its feasibility. The question was, why was it not more generally adopted, and perhaps the cost had something to do with it. He understood the expense would be about £5 per truck, which would be about 3 or 4 per cent. on the cost, and probably on passenger carriages rather more; but even then, he thought it would prove economical. He hoped the thin end of the wedge would soon be introduced, and that the system would spread until it was universal. He concluded by moving a vote of thanks to Mr. Brockelbank.

The motion having been carried unanimously,

Mr. Brockelbank, in reply, said he regretted there had not been more discussion, but he attributed it to the fact that he had limited himself entirely to a matter which involved a large number of figures, and these had taken him so long to study, that he could hardly anticipate they could be taken in at once. He had purposely avoided touching on the mechanical portion of the question, because it was a subject on which there was so much to be said. With regard to the trials to which reference had been made, he would merely say that they were made before the officials of the Great Eastern and other companies, and the then chief engineer to the Board of Trade, and he was able in the shunting yard to execute all the work which was required. The next point, which had yet to be worked out thoroughly, was how these operations would succeed in the actual working of the traffic. Many inventions had been brought forward, some of the most admirable character, but as yet they were all in this condition, as was his also, that until they were put into actual work their value could not be properly tested. As he had said, railway companies had an entire monopoly, and until they would try this system practically, it must remain

an unsettled question. With regard to the Continent, the report to the Royal Commission on Accidents, made by a engineer sent specially to report on the subject, was that there was no automatic or mechanical system of couplings in use on the continent. His own experience, after conversing with various engineers in every one of the principal countries in Europe, was that England led the way, and when English engineers had settled which automatic couplings they would adopt, the continent would follow.

A Member suggested that it would be a good plan to introduce the system on some small line which worked itself, and had no interchange of traffic.

Mr. Brockelbank said he was the only inventor of an automatic coupling at the present moment who had authority to fit up the entire rolling stock of a railway with his couplings; but, owing to the present commercial depression, he had not yet been able to find the means to carry it out. As soon as he could get the necessary funds, the experiment would be tried.

MISCELLANEOUS.

EDUCATION IN SMYRNA.—EUROPEAN OR FOREIGN POPULAR INSTRUCTION.

By S. Stab,

Consul-General of Guatemala and Liberia, in Turkey, Corresponding Member of the Society of Arts.

Part II.

In the first part of my educational report, I treated the subject of native popular instruction, but I did not comprise in it the native Roman Catholics, for the reason that this community, almost without exception, send their children to schools established either by the French religious missions, or such schools as are kept by foreigners.*

It is a notorious fact that the extensive commerce of this city long ago attracted a number of foreigners who settled here, and the commercial progress and the enlightment of the natives is certainly due to them. Although the descendants of many of these foreigners have been absorbed and amalgamated with the native Christian element, still the majority have claimed the nationality and creed of their forefathers. In the early times of the foreign settlement here, the clergy of the different sects had to give to the children of their respective flocks rudimentary education, but this has much changed within the last half century, during which period a number of private and public schools have been founded under the direction of laymen, where improved instruction is given. However, without entering into a retrospective description, I will merely limit myself to the educational establishments actually in existence.

Gratuitous Instruction.—Roman Catholics.

Ecole de Frères.—In addition to the elementary instruction given to poor children of both sexes at the various convents existing here, the school of the Frères de la Propagation de la Foi of France (or Propaganda Fide), was established in 1841. It is supported by a subvention from the French Government and the Propaganda of the same country, as well as by local charitable contributions. Children of all religions denominations are invited for free instruction. The school is divided into 8 classes, and there are 11 priests as teachers, with 404 pupils, 354 of whom are Roman Catholics, and 50 belong to other sects, namely, Greeks, Armenians, Jews, &c. The language of instruction is French, and the education given aims at preparing the youth for commercial pursuits. Other languages are taught if desired, but these must be paid for. In addition to the usual elementary instruction given, such as geography, history, natural history, arithmetic, and religion, &c., book-keeping and commercial correspondence are taught. This school possesses a small cabinet of natural history.

Boarding Schools for Boys.

Collége de la Propagande.—The present college of the Propaganda, which went formerly by the name of "Collége de l'Archevêché," has been re-organised by the Lazarist brotherhood in 1845. The programme of instruction and of the books employed is based on the system of that followed by the French Lycées. French is the language of instruction, but Greek is an obligatory language. During the last scholastic year there were 85 pupils, 45 of whom were whole boarders, 25 day boarders, and 15 day scholars, all of them Roman Catholics. The institution has a library of 10,000 volumes, as well as a "cabinet de physique," or collection of philosophical instruments. Pupils who finish their studies in this college can present themselves at any French University for examination for the degree of *Bachelier es-lettres*. With the exception of a small subvention from the French Government, the school is supported by the fees of the scholars.

Institution des Mekhitaristes.—This school, which is under the direction of the Mekhitarist Armenian brotherhood of Venice, was founded in 1847, and, besides the preparatory and philosophical classes, it is divided into six divisions. There were during the last scholastic year 100 pupils, 25 of these were whole boarders, 25 day boarders, and 50 day scholars. According to religions denominations 71 pupils were Roman Catholics, 16 Gregorian Armenians, 8 Greeks (orthodox), 3 Mussulmans, and 2 Jews. The programme of instruction comprises, besides French, which is the language of instruction, Greek, German, and Italian mathematics (arithmetic, algebra, and geometry), geography, cosmography, universal history, natural history (zoology, botany, and mineralogy), chemistry, natural philosophy, commercial correspondence and book-keeping, drawing and calligraphy. This school is subventionised by the Austrian and Italian Governments, but its resources are principally derived from the fees of the pupils.

The English Commercial School, Smyrna, under the direction of Mr. W. C. Barkshire, certificated master, Normal College, Cheltenham.—As its title indicates, the principal scope of this school is to prepare youths for a commercial career. Notwithstanding that this educational establishment has only been founded a few years, such is the progress made that it already surpasses some of its older sister-schools. Actually there are about 140 pupils, of whom 35 are boarders, 30 day boarders, and 75 day scholars; divided into religious persuasions there are 30 Protestants, 25 Roman Catholics, 50 Greeks, 30 Armenians, and 4 Jews. The teaching staff consist of 17 teachers, viz., 3 English, 3 French, 3 Greek, 2 Armenian, 1 German, 1 Turkish, 1 Latin, 1 drawing, 1 music, and 1 for book-keeping. The languages taught, as will be seen by the classification of the teachers, are English, German, French, Greek, Turkish, Latin, and Armenian. Scientific lessons are given simultaneously in English, French, and Greek. In addition to the elementary and preparatory instruction, the curriculum of studies in the higher classes consists of sacred and universal history, geography, natural history, arithmetic, geometry, algebra, mensuration, chemistry, natural philosophy, book-keeping, commercial correspondence, writing, singing, drawing,

* The native Roman Catholics are generally the offspring of united Armenians, with a sprinkling of Levantines, mostly of Greek descent, also some Syrians and Europeans. It is noteworthy that although the broken Greek generally spoken in Smyrna serves as the mother tongue of that community, few learn the modern literary Greek.

&c. The text-books employed are those most generally adopted in similar establishments in England and France.

The British College, Smyrna, under the direction of Mr. J. Barth.—This school was established in 1851 by Mr. Samuel Sheppard, an Englishman, now dead, with a view to give a thorough English training to its inmates, from the elementary branches to the highest programme of instruction given in superior schools in Europe. French and English are the languages of the scientific instruction, but English is the predominating one, and during the recreation hours it is obligatory. There are 6 divisions for English, 6 French, 6 Greek, 4 German, 2 Turkish, and 2 Armenian. The average number of pupils for the last ten years was about 100, 60 of whom were whole or half boarders, and 40 day scholars. As to religious professions there were 35 Greek orthodox, 15 Armenians, 25 Protestants, 22 Roman Catholics, and 3 Mussulmans. The teaching staff consists of 4 English, 3 French, 2 Greek, 1 German, 1 Turkish, and 1 Armenian masters. The programme of studies includes, besides the elementary classes, the languages, writing, sacred history, English and universal history, natural history, philosophy, natural philosophy, mythology, literature, arithmetic, geometry, algebra, drawing, &c. There is a special commercial course, consisting of book-keeping, correspondence, and commercial law. There is also a special course in Latin for pupils who intend to enter a university; their admittance, however, depends upon an examination they have to pass. Several pupils who finished their studies in this college have been admitted into German and French universities.

Burnabat English College, founded in 1850.—This educational establishment was one of the first superior schools of the kind founded in this place by Mr. F. W. Turrell, its present principal, who is assisted by five teachers. There are about 30 scholars, three-fourths of whom are either whole or half boarders, and the remainder day scholars. The pupils belong to almost all the religious denominations professed here, namely, Protestants, Roman Catholics, Greeks, Armenians, Jews, and Turks. Besides the languages taught, such as English, German, French, modern and ancient Greek, Latin, Turkish, and Italian, the general course of studies includes mathematics, history, geography, natural history, &c., and is based upon that pursued in first-class establishments in England. Several pupils educated at that institution have passed, with honours, first class Oxford and Cambridge local examinations in England. The college is at the neighbouring summer town and railway station of Burnabat.

The Italian National Free School.—The Italian language, which was once the predominating one among the Frank population of this country, was quickly superseded by the French after the introduction of the French missions all over the Levant, so much so that actually few of the native born Italian subjects of the present generation know Italian at all. This state of affairs has moved the Italian Government to take steps to revive the community of feeling between the mother country and its colonies in the East, and, with that view, an annual sum of £156 was allotted to Smyrna on the budget of public instruction. This amount is distributed in the following way:—National School, £132; Mekhitarists, £20; Capuchin Friars, £4. As yet this school is merely an elementary day school, where about fifty children of Italian artisans, born here, are instructed in the elements of the Italian language. It is, however, expected that shortly a law will be passed in the Italian Parliament authorising the Minister of Public Instruction to establish a higher class of school in this city. Such a superior school already exists in Alexandria, Egypt.

The Capuchin Friars have also a day school with thirty to forty children, mostly of the large Maltese colony in Smyrna; the elementary instruction given to these children is in Italian, and they are not taught English.

Boarding Schools for Girls.

Deaconesses Institute, Smyrna.—This institute was founded in this city exactly a quarter of century ago, by the present directress, Sister Mina. Modestly started with two German sisters, this educational establishment has continued its onward progress, so that actually it has a teaching staff of 27 persons, among whom are 12 sisters, and be it said, to the credit of its directress, the institute may be reckoned as one of the best in Smyrna. Although founded for Protestants, children of all creeds are admitted. Exclusive of the preparatory class, the school is divided into four classes, the third and fourth of which are again subdivided into two sections each, *a* and *b*. French is the language of instruction, but German is equally obligatory, while the English, Greek, and Armenian children are in addition taught their respective mother tongues. During the last scholastic year there were 210 pupils, 58 of whom were boarders, 67 were Greek orthodox, 28 Gregorian Armenians, 19 Roman Catholics, 10 Jews, and the remaining 86 Protestants. As most of the English young ladies are sent to the school, they receive a special English education, and it has been looked upon by the colony as the chief English boarding school. The general programme of studies comprises in the superior classes sacred and universal history, grammar, literature, geography, zoology, botanic, mineralogy, physics, arithmetic, and composition. In the middle classes, modern and ancient history, natural history, arithmetic, grammer, and composition. Drawing, writing, singing, and needlework, are taught in all the classes. Pianoforte lessons are also given, but charged for extra.

Pensionnat de Notre Dame de Sion (Roman Catholic).—The groundwork of this educational establishment was laid in this city two years ago by the sisterhood of the above order. Although only of recent existence among us, this school is already well patronised, particularly by the Roman Catholics of this place. During the last scholastic year they had over 70 pupils, about two-thirds of whom were boarders or half-boarders, and the remainder day scholars. French is the language of instruction, but English, Italian, German, and Greek are also taught, if desired, but charged for extra, as are pianoforte lessons. The programme of studies comprises religion, church history, writing, grammar, and French literature, history of literature, arithmetic, geography, ancient and modern, natural history, elementary physics, domestic economy, elements of the Greek language, vocal music, drawing and painting.

Pensionnat des Quais, Français-Anglais, directed by Madame Canouil and Miss Knevett.—This school was founded about ten years ago as a cosmopolitan educational establishment, that is, without the patronage of any religious body, as in fact all the other European girls' schools in this city are. Till the arrival of the Dames de Sion, this school was patronised by the best families of Smyrna, but with the creation of that boarding school, the number of pupils has very considerably decreased. Actually there are about 25 to 30 pupils between boarders and day scholars. French and English are conjointly taught; the rest of the studies comprise the same subjects as at the Deaconesses.

Pensionnat des Soeurs de Charité à Burnabat (Roman Catholic).—There are about 40 pupils (mostly Roman Catholics), between boarders, half boarders, and day scholars frequenting this suburban school. The instruction given in this school is based on the same principle and system as that adopted by the Dames de Sion. French is the language of instruction, but Greek is also taught.

Ecole de Soeurs de Charité à Smyrne (Roman Catholic).—This inferior day school is frequented by

about 40 Roman Catholic children. The instruction given is based on the same system as the above school.

The British School (Protestant).—This school was founded a few years ago by a number of benevolent Englishmen living here. The school is intended to give an English training to the children of English artisans and others employed on the two railways existing here. At present it is an elementary day school for boys and girls, and there are only from 25 to 30 children frequenting it, but in order to facilitate the attendance of those who live some distance away, arrangements are being made to accommodate boarders and half-boarders.

Charitable Institutions.

The Orphan Hospital of St. Joseph (Roman Catholic).—This charitable establishment forms a kind of model farm, and is situated on the outskirts of the city; it was founded over a quarter of a century ago by the sisters of charity of St. Vincent and Paul. It receives under its roof not only orphans, but all Roman Catholic children who, from one reason or another, are deprived of any parental care or assistance. The asylum is superintended by 10 to 12 sisters of charity, who bestow a truly maternal care on those poor helpless beings till the rite of confirmation has been performed. The religious instruction is confided to the care of a priest of the Lazarist order attached to the establishment. The number of children actually sheltered under the roof of this asylum is about 130 of both sexes. The basis of education consists in the first instance of religion, also as far as possible some trade. The instruction in the elements of the French and Greek languages; a few indispensable notions of arithmetic, history, and geography are given morning and evening; the rest of the day is employed in teaching the boys some trade, such as joiners and shoemakers, but the majority of them are employed in rural pursuits and cattle feeding, while the girls are employed in a separate building destined for them in sewing, cooking, ironing, and housekeeping. The children leave the establishment at the age of 12 to 14 years, and are placed with respectable families in town. I may add that these children are generally found to be industrious and well-behaved. The children are healthy and robust, but more particularly this is the case with the girls.

The Sisters of Charity, at Burnabat, have also established an orphan asylum at that place, the inmates, about 20, are all girls, and the same system of education is followed there as in the former charitable establishment.

The Prussian Deaconesses, too, have attached to their educational establishment a Protestant orphan asylum. There are about 30 children in it now belonging to almost all the communities living here.

Notwithstanding that almost all the European schools here are on a remunerative system, the poorer classes of foreign children find always a liberal allowance on the fixed fees, and in many cases entire remission of them.

Intellectual Progress.

The intellectual activity of the Smyrniots is not a little remarkable, the press and number of works published here during the last 20 years, both original and translations, being an evident proof of the result of the education above described. I will follow here the same system as adopted in the beginning of my report.

The Greeks.—The educational and intellectual activity of this community, and the unrelenting zeal with which they persevere in the path of progress is commendable in the highest terms. Within the last 20 years not only has modern Greek literature made a great stride, but even the colloquial language of the people, formerly a gibberish of all dialects spoken in the East, has now been a good deal altered. Greek scholars in Europe will now easily understand a book or an article of a Greek newspaper, and all this is due to the order with which every one vies to contribute towards the common object. The number and quality of the schools, the properly qualified teachers, the literary clubs, the circulating libraries, the national theatre, have encouraged a number of original authors and translators of foreign standard works, and these in their turn have created a number of industries in printing, engraving on wood, stone and metal; all this, I say, has been accomplished within a comparatively short period in this city. To enumerate all the original works and translations published here of late years would be overstepping the limits of a simple report, I will, therefore, restrict myself to a few titles:—"Essay on the History of the Greek Language," "Greek Grammatology," "General Structure of the Greek Syntax," "Compendium of the Greek Grammar," "Course of Elementary Lessons," "Instruction of the Greek Language," "Essay against Superstition," "The Instruction of the Greek Oriental Church," "Christian Doctrine," "Compendium of Ecclesiastical History," "Moral and Political Stories," "Compendium Guide for the Instruction of Boys," "Encyclopædia for Girls," "Dramatical Representations," "Greek History Biographically Described," "History of the Turkish Empire," "Elementary Geography," "Consta, the Fratricide," "Elements of Chemistry," "Cléodemos, or the Expulsion of the Goths from Athens," "Two Nights with the Tempter," "A Lexicon of Modern Greek-English and English-Greek," "Ollendorff's Method Applied to the Greek Language," "New Ollendorff's Method for Prompt Instruction of the French," "Key to Ollendorff's Greek and English Method," "Code of the Evangelical School," "The Ancient Weights of Smyrna," "Catalogue of the Manuscripts of the Library of the Evangelical School," "About a Mould of Ancient Weights," "The Stone Epoch," "The Smyrnean," that is to say, an historical and topographical study of Smyrna.

Translations.—"The Apostle Paul," by Newmann; "The Divine Human Figure of Our Lord," by Schaff; "Dictionary Encyclopædian"—D'Arteau; "Description of Asia Minor," by Texier; "Notes on the King Œdipus" (in rhymes); "Xenophon the Ephesian;" "Logical Arithmetic," by Henry Bermier; "New Method of the French Language," by Hahn; "A Treatise on the Wine of St. Raphael," by Delavigne; "Library of the Stage;" "How we Found Livingstone," by Stanley; "The English Expedition to the North Pole;" "20,000 Leagues Beneath the Sea," by Jules Verne.

Reviews.—"Mentor," "Pythagoras," "The Reading-room, Smyrna," "Homer," "The Oriental Review"—all these monthly. "Okélès," occasionally; "The Library of the People," occasionally; "Museum and Library of the Evangelical School," annually; "Bion," monthly.

Newspapers.—*Amalthea*, founded in 1837, published twice a week; *Smirna*, founded 1869, published daily; *Proodos*, founded 1871, published twice a week; *Lonie*, founded 1877, published twice a week; *Velos*, satirical paper, founded 1877, published twice a week; *Tlarotis*, founded 1876, published twice a week.*

The Turks, within the last few years, although most of their works are produced at Constantinople, have, nevertheless, published a few original works, which are the following:—"Tasshil el Cavafi," conversation in rhyme; "Fcckai Divani," 1 vol., poetry; "Lolughat Turkia," a dictionary; "Servetin Maaragiasi," pious poetry; "Muhtesser hisab," a synopsis of arithmetic; "Ismir Tari Khi," a history of Smyrna (in the press); and "Mizrakli," "Tedjvid," "Sonfar Soubian," school books. Two Turkish newspapers are also published

* The following are the principal authors of the above mentioned original works:—Messrs. Mavrofrido, Efstadopolon, Karagannis, Economopolo, Lelion, Xanthopolon, Karidon, Savaidon, Scolarin, Leonidiadus, Xamidopolon, Stai, &c.

here, the *Aïdin* (official), published twice a week, and the *Tsmir*, published daily. Several school books have been published here, but most of the Turkish books are imported from Constantinople.

Jews.—Several school books have been published here in Hebro-Spanish, and a large number of religious books have also appeared within the last 20 years. The following is a specimen of the books issued from their printing establishments:—Religious books—"Haïm ve Shalomon," 2 vols.; "Birkat Mnaveha Leleham," "Halkam Behaïm," "Sedaka Haïm," "Haïm Beyath," "Gishna Haïm," "Kaper Lehaïm," "Sava Mehayim," "Refua ve Haïm," "Pohahah Haïm," "Zohoreno Lehaïm," "Shemo Noshé," "Yakail Sholomo," "Yeme Sholomo," "Porat Yossef," "Vaikra Yossef," "Oraha Debeddin," "Pevosha Genda," "Yad Gemin," "Megalé Sefunot," "Mizbea Eliao," "Yado Bahol," "Ene Aïda," "Michta Lehizkiavn," "Divar Meshbat," "Ezbaki Pana," "Pikune Azuor," "Zoar Akadosh," 7 vols., "Yafé Laleve," "Avod Arosh." Hebro-Spanish—"Shevet Muserz-Derah Sedaka," "Ahavod Tiscor," "Meamluez Toshna," "Misterios di los Judeos," "Passio d al Gioco," "El Salvador," "Rachel nel Convento," "El Cico Eleazer," "El Conde i el Judeo," "El Matadore in Convierto," "Storia de Don Salomon Abravenel," &c. There is also a weekly newspaper published in Hebro-Spanish called the *Esperanza.*

Armenians.—Original works in Armenian—A "General History," 3 vols.; "The Death of Bored," 1 vol.; "Anouchavan," 1 vol.; "Mirza and Anna," 1 vol. Novels—"Armenian Secretary" (epistolary); 17 different school books in Armenian, 2 in French, and not less than 102 vols., novels and other works, translated from French were published here. The most conspicuous of the latter are:—"Le Tour du Monde en 80 Jours," "Les Misérables," "Le Maudit," "Monte Cristo," "Les Mystères de Paris," "Les Milles et une Nuits," "Notre Dame de Paris," "Vingt ans apres," "Histoire Ottomane," "Catherine Howard," "Paul et Virginie," &c. There are also two reviews published in Armenian, "The Arévélian Mamoul" ("The Eastern Post"), weekly; "The Archalouis Araradian" ("The Dawn of Ararat"), fortnightly.

It is but fair to state that the above large quantity of intellectual matter, both original and translated, is due to the assiduous zeal and labour of Messrs. Mamourian, Chilingeurian, Badganian, Parhondarianz, Nubarian, &c. The Armenian community cannot but be equally grateful to the publishers of the above-named works, Messrs. Dédeyan, who, by risking a large amount of capital in these publications, have not only encouraged Armenian literature in Smyrna, but over the whole of Turkey and over Russia, and, therefore, mainly contributed to the intellectual progress of their nationality.

The European Community find it advantageous to get their school books from Europe, and even any original works written here are sent for publication to Europe. Among these latter I may quote M. de Scherzer's "La Province de Smyrne;" "The Letter of Recommendation," by P. Worth, &c. Still some have been published here, viz., "Guide de Smyrne," by Slaars; "Mes Loisirs à Smyrne" (poetry), by M. Bon; "A Treatise on the Opium Cultivation," by Heffter. School books—"Choix Gradué de Lectures Françaises," L. Casé; "Petite Encyclopédie Classique," Do. A large number of pamphlets and other small works have appeared in French and English from time to time, some on scientific subjects. Two newspapers published in French appear in this city, the *Impartial* and *Réforme*, both bi-weekly, and a supplement of the *Impartial* daily.

CONCLUSION.

I own that the standard of the educational system pursued here is far from impressing the youthful mind with a practical knowledge of arts and sciences, but at the same time it must be borne in mind that trade is the only occupation of the non-Mussulman urban population in this country, and such being the case, it is gratifying to find that instruction has not only been pretty widely propagated in this place, but has actually penetrated the substratum of the working-classes of all persuasions; this encourages us to look forward hopefully for a brighter future. This earnest desire to acquire the benign gift of knowledge is obvious from the number of the 58 schools, with 6,938 pupils frequenting them. It is also computed that about 4,000 children, exclusive of the above total, receive instruction in the numerous day schools of each community, of course, including the Mussulmans, whose number I could not obtain for the first part of my report, which, however, I ascertain to be over 400 children attending their schools. This would make a grand total of nearly 11,000 children on a population of 118,944. True, a few of these children come from the interior.

I must here allude to the difficulties the generality of pupils have to overcome in mastering the technology of arts or sciences; this is particularly the case with the Mussulman children, as well as those who frequent the European schools, and this through the want of a literary mother tongue. Thus the Mussulman speaks Turkish, but his books are an amalgam of Arabic and Persian; the Roman Catholics and Levantines in general speak the Greek *patois*, while their studies are made either in French, English, &c. This same difficulty applies to some extent to the Greeks, Armenians, and Jews, all and each of them speak their own *patois*, which differs greatly from their respective literary tongues. For multifarious pursuits a better training place could hardly be found. From a very tender age, the ear of the child gets accustomed to the several dialects spoken here; combined with a little study in later age, he sets up as a polyglot. Notwithstanding the difficulties alluded to above, many young men who finished their primary education here have been admitted into the universities of Greece, France, and Germany, and indeed it is gratifying to say that some of the officials presiding over the destinies of this Empire have been educated in Smyrna.

Erratum.—Instead of "intolerant" as stated in the first part of my report read "rather tolerant."

RAILWAY WORK IN JAPAN.

At a recent meeting of the Institution of Civil Engineers, Mr. W. Furniss Potter read a paper on "Railway Work in Japan," in which the following information was given:—

There are at present $66\frac{1}{2}$ miles of railways in Japan, $142\frac{3}{4}$ miles laid out, with working plans, sections, and estimates completed, and 455 miles projected, the general route only having been examined and decided upon. The earthworks of the existing lines had been made for a double way, and the bridges for a single way. The permanent way was of double-headed 60 lb. rails on the Yeddo-Yokohama and Kobe-Osaka lines; but on the Osaka-Kioto line, 60 lb. flat-bottomed rails on cross sleepers were used. The superstructure of the smaller bridges was originally of timber, but had been renewed with iron. The larger bridges were all of the Warren girder type, and as a rule of 100 ft. spans. The foundations were on brick wells 12 ft. in diameter, and on an average about 60 ft. deep. Native examples of engineering were chiefly remarkable for their temporary character. The usual foundation for the largest buildings was only a few stones on the surface of the ground. The natives were very clever in making artesian borings for water, and a detailed description of the *modus operandi* was given. The workmen were extremely intelligent and industrious, especially

the carpenters, who were by far the most numerous and skilful. The wages of first-class carpenters were 1s. 8d. per day; of blacksmiths, 1s. 6d.; of bricklayers and masons, 1s. 5d.; and of coolies, 11d. Materials found in the country for construction were not very good, except timber, which was abundant. No limestone possessing hydraulic properties had been found. It was impossible to furnish any reliable information as to the cost of the works, as the Japanese officials avoided giving particulars on this point to the foreign staff. The chief engineering difficulty in Japan was the treatment of the watershed. The beds of the rivers were nearly all higher than the surrounding country, varying from a few feet to 40 feet, or more. In some instances the railway had been taken under the rivers by tunnelling, and an example of this was given. As a rule, however, the rivers were bridged over, and approached by steep gradients and high embankments. The flood waters were confined in the rivers by huge banks which were gradually built up by the natives, as the beds of the river became silted up, and were frequently formidable works. The general character of the country was a series of highly-cultivated and well-watered plains, bounded by ranges of hills of the metamorphic formation. Where these hills had to be crossed there would be some heavy works. These features were described in detail. The traffic on the railways already constructed was considerable, and it was estimated that on future railways the passenger traffic alone would pay a dividend of 7 per cent. Not much had been done in goods traffic, as the existing lines were in competition with the water communications. In the future development of railway work in Japan, two essential points were necessary, greater economy of construction, and the introduction of English capital and enterprise. These could be obtained if the principle of surface lines were adopted, and the natural jealousy of the Government of foreign interference were abolished.

FISHERIES OF THE CANARY ISLANDS.

Consul Dundas states that the fisheries in these waters have been drawing much attention of late, and in proper hands they would develop into a source of considerable wealth—perhaps, the greatest, certainly not the least wealth-producing source of these islands, by no means wanting in this respect. It is asserted that the fish are in general inferior in quality to those of Scotland or of British North America, but the imperfect and careless manner of curing them may account for this assertion. M. Berthelot, late French Consul, in his work, draws a comparison with the fisheries of Newfoundland. After elaborate numerical calculation derived from practical results, he comes to the conclusion that the quantity of fish caught by one man in the Canaries is equal to that caught by twenty-six men in Newfoundland. All evidence tends to show that the quantity caught is very great, and that the supply is inexhaustible. And yet neither the native fishermen nor the commercial community of the islands have endeavoured to turn this immense field of wealth to any advantage, being satisfied thus far with confining their operations almost exclusively to the supply of the local consumption. The largest fish banks are said to be from the Island of Fuerteventura to Cabo Blanco. The vessels fish down to the latter point, and the larger ones sometimes go very near to Cape de Verd.

In 1864, a Spanish company was formed, having obtained a concession from the Government to fish in these waters on a large scale. An Englishman was engaged to superintend the business, who brought with him several intelligent operatives from England and Scotland. Some barrels of dried and pickled fish were sent to Spain, and are reported to have been much liked. But the death of the originator occurring shortly afterwards, and the want of funds, caused the break-up of the establishment. There is, however, a very possible probability that fish will in future be exported from the Canary Islands, and that in considerable quantities. A French company in Marseilles has lately made a contract with the owners of the fishing vessels, by which the company is to receive as much fish as they can supply, or the company can take.

The fishing boats are employed nearly all the year, but the best season is during the winter months, say from September to October to the end of March; the fish then are in great numbers and in best condition. There is one summer month—June—in which fish are very plentiful, or more correctly speaking the latter half of that month. The class of vessels employed in this occupation, formerly top-sail, are now fore-and-aft schooners, varying in size from 25 to 50 tons; they carry crews of from 18 and 20 to 30 and 40 men and boys, and are provided with two, three, or four boats. No nets are used, the fish being caught with hooks. Besides the different kinds of hooks and lines, they also carry rods or poles of from five to six feet in length, to the end of which is attached some six feet of line trimmed with several strong rough made hooks at a certain distance from each other. These are trailed along the surface of the water; a means of capture which frequently fills the vessels rapidly. They steer by the sun or stars, the compass being either unknown or its use despised. The crews, many of whom are boys, are not paid any wages, but a share in the profits, and it is a rule on board that until all the fish caught during the day has been salted no dinner or supper shall be served. The total number of vessels composing the fishing fleet in these islands is reckoned at 20, of which 14 belong to Grand Canary, the rest to Palma, Fuerteventura, and Lanzarote.

As the fishing varies greatly according to circumstances, it is somewhat difficult to give a reliable average. It frequently happens that a vessel is out weeks before filling up a cargo sufficient to return with, and at other times they fill up in an incredibly short space of time; and when judging the quantity taken and the time it is taken in, the rude means employed must not be lost sight of, whereas if nets were used, the proportion would be much larger in a shorter space of time, though the wholesale destruction would probably be greater. According to the owner of one of these fishing schooners, one of those now under contract with the French company mentioned, four boats, under favourable circumstances, could deliver in less than two days more fresh fish than the steamer could carry. Ordinarily speaking, a boat of 40 tons might be loaded in three days. Other estimates give the catch per vessel per diem at from 15 to 30 quintals of 900 lbs. each. But there are days in which 50 quintals have been taken, and others again when not even 10 quintals have been caught. Cases are numerous of a vessel of 30 tons or so filling up in two days, when they happen to come on a bank where the fish has been drawn or scared from other banks in large shoals.

It is equally difficult, says Consul Dundas, to give a correct estimate of the weight of the fish, which also varies considerably; but for practical purposes it may suffice to say that most of them run 15 to 65 lbs. each, the greater proportion being from 20 to 30 lbs. Very small fish are rejected, and very large are objected to. The fishing ground may be considered as lying between the southern part of the island of Grand Canary and the same latitude on the African coast, or from about 15° to 32° or 33° north latitude along the north-west coast of Africa. The annual quantity caught is estimated at from 5,000 to 8,000 tons; the salting is done on board the vessels. It must not be supposed that cod-fish is the sole fish comprised in these fisheries; it does not bear a larger proportion than one-quarter or one-third, according to the season, of the total.

NEW COMMERCIAL PLANTS.

Under the above title, Mr. Thomas Christy, of 155, Fenchurch-street, has issued another of his pamphlets, which treats of products either quite new to commerce, or of those that have been for some time known but have not come into general use. These pamphlets demonstrate at once the truth that the world does yet contain a vast field of unappropriated wealth, and it is only by constant watchfulness, or a keen perception of what is really valuable, that the fine metal is separated from the dross, so to speak, and new commercial products are established in our markets. The discovery of new rubber-yielding plants, and the extended geographical range of well known species, are matters that have often been referred to in these pages, and in the pamphlet under consideration a new rubber plant is described, and figured under the name of *Urostigma bogelii*. Referring to this class of plants, Mr. Christy says in his preface :—"A great many plants yielding india-rubber are now known to botanists, and more are being discovered every year. Comparatively few, however, are fit for general cultivation; some which yield excellent rubber do not produce an adequate return until after many years, others require certain peculiarities of soil and climate for their successful culture; while others, again, which possess the advantages of rapidly coming to maturity, and of being easily cultivated, yield a rubber of low commercial value."

There are, perhaps, few questions in economic botany regarding substances of such great commercial importance as india-rubber, where the plants producing them are involved in such mystery. It is to be hoped that by the energy of collectors abroad, supported by such men at home as the author of the pamphlet in question, a true knowledge may soon be obtained of these botanically and geographically widely diffused plants.

Mr. Christy draws special attention to the *Gynocardia odorata*, or the tree yielding the Chautmugra oil, as one of the most important plants for introduction into all tropical countries, on account of the great therapeutic value of the oil obtained from the seeds. This oil has long been known, and valued highly in "India and China as a remedy for skin diseases and other complaints due to impurity of the blood, and as a specific for secondary syphilis. . . . . In the Mauritius it is considered to be the only reliable remedy for leprosy, and so high a value is put on its purity that the seeds are imported from India for the purpose of obtaining the oil free from adulteration. . . . . The pure oil in India is expensive, and therefore offers a great inducement to the natives to adulterate it; indeed, adulteration is carried to such an extent, and is so difficult to detect, that it has occasionally caused medical men in India to discontinue its use. Preference should, therefore, be given, in purchasing the oil, to that which has been expressed from the seed in this country." It is chiefly in the cure of consumption that this oil is now used, and is strongly recommended by many medical men of note. Among the public institutions where it is now in use may be mentioned St. Peter's Hospital, Berners-street, the Margate Infirmary, the Hospital for Diseases of the Chest, City-road, St. John's Hospital, Leicester-square, &c. From the satisfactory effect of this oil in many reported cases it seems that its general adoption is insured, as in India a good deal, nay, nearly all depends upon the purity of the oil supplied, and complete purity is guaranteed in the oil furnished by Mr. Christy.

Another plant of India which deserves more attention in this country than has hitherto been accorded to it is the maliwall (*Bassia latifolia*), which is very abundant in all parts of India, both in a wild and cultivated state. The most valuable product of the tree is the flowers, which are produced in enormous quantities, and fall to the ground so thickly when fully ripe as to form a dense carpet. These flowers are gathered each morning, and stored by the natives for winter use. They contain a large quantity of sugar, and a strong spirit is distilled from them, very similar in flavour to Irish whisky; this spirit has been proved upon analysis to be very wholesome, and when carefully rectified can be obtained exceedingly pure.

Such then are some of the products of the vegetable kingdom new to commerce in this country, the introduction of which are due to the energy displayed by Mr. Christy.

CORRESPONDENCE.

THE BAMBOO.

In reference to the valuable communication of Mr. Routledge, allow me to suggest that the Terai, in the Darjeeling district, and elsewhere throughout its belt, may afford the requisite conditions for the bamboo.

HYDE CLARKE.

32, St. George's-square, S.W.,
9th Jan., 1879.

GENERAL NOTES.

Ventilation of Waterproof Garments.—An ingenious method has been devised and patented for securing this desideratum, and is put in practice by Messrs. Harvey, Bartrum, and Co. The fabric consists of three parts; ordinary cloth outside, a thin sheet of vulcanised india-rubber next to it, and an inside lining, the three pressed together in the usual way forming the waterproof cloth. In the manufacture of the garment, the inner lining is separated in a portion of the back, and under the arms and inside the sleeves; in these parts perforations are made in the india-rubber. An additional piece of waterproofing rubber is put on the separated portions of the lining which are also perforated. Air passages is thus formed, allowing air to pass freely to the body. The two series of perforations are placed so as not to come opposite to each other. External wet is thus excluded, and internal vapour and moisture can escape.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at Eight o'clock:—

JANUARY 22.—"The Modern Science of Economics." By HENRY DUNNING MACLEOD, Esq., Barrister-at-Law.

JANUARY 29.—"The Distribution of Disease popularly considered." By ALFRED HAVILAND, Esq., M.R.C.S.E.

FEBRUARY 5.—"The Best Methods for Improving the Condition of the Blind." By Dr. T. R. ARMITAGE.

FEBRUARY 12.—"The Application of the Bessemer Process to the Reduction of Metallic Sulphides." By JOHN HOLLWAY, Esq.

FEBRUARY 19.—"Turkey and its Resources." By J. L. HADDAN, Esq. Lieut.-Gen. Sir A. B. KEMBALL, K.C.S.I., C.B., R.A., will preside.

FEBRUARY 26.—"Indian Pottery at the Paris Exhibition." By GEORGE BIRDWOOD, Esq., M.D., C.S.I.

MARCH 5.—"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By JOSEPH J. POPE, Esq., M.R.C.S., L.S.A.

March 12.—"The Compensation of Time-keepers." By Edward Rigg, Esq., M.A.

March 19.—"Economical Gardens for Londoners." By W. Mattieu Williams, Esq., F.R.A.S., F.C.S.

March 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor Barff, M.A.

Chemical Section.

Thursday Evenings, at Eight o'clock.

January 30.—"Gas Illumination." By Dr. Wm. Wallace, F.R.S.E.

Indian Section.

Friday Evenings, at Eight o'clock.

January 17. — "Affghanistan." By C. E. D. Black, Esq. Col. H. Yule, C.B., R.E., will preside.

January 31.—"Quest and Early European Settlement of India." By George Birdwood, Esq., M.D., C.S.I.

February 21. — "The Trade of Central Asia." By Trelawney Saunders, Esq.

March 7. — "The Moral and Material Progress of India." By H. Phillips, Esq.

African Section.

Tuesday Evenings, at Eight o'clock.

January 21.—"Retrospect and Prospect in Egypt." By B. Francis Cobb, Esq.

February 4.—The Opening of the District to the North of Lake Nyassa, with Notes of a Recent Expedition through that Country." By H. B. Cotterell, Esq.

March 18.—"Some Remarks upon an Old Map of Africa contained in Janson's Atlas, published at Paris in 1612." Communicated and exhibited by R. Ward, Esq.

April 1.—"The Contact of Civilisation and Barbarism in Africa, past and present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

Cantor Lectures.

Monday Evenings, at Eight o'clock. First Course, on "Mathematical Instruments." Six Lectures, by Mr. W. Mattieu Williams.

The report of the Fourth Cantor Lecture, on "Mathematical Instruments," will appear in next week's *Journal*.

Lecture V.—January 20, 1879.

Instruments for Measuring Mass.—The scale beam—The steel yard — The spring balance — Laboratory balances—Cavendish's torsion balance for weighing the earth—Weighing the earth by plumb-line—Weighing the earth by pendulum. *Instruments for Measuring Short Intervals of Time and Great Velocities.*—Wheatstone's and Foucault's mirrors—The chronograph—The spectroscope as applied to the measurement of velocities.

Lecture VI.—January 27, 1879.

Instruments for Recording or Representing Results of Mathematical Processes.—Plotting and Drawing Instruments.

These lectures will not be addressed to mathematicians, but the subject will be treated in simple and elementary forms; any technical term that must necessarily be used will be explained when introduced.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Household Sanitary Arrangements." It will consist of Six Lectures, to be given on the following dates:—

February 17, 24, March 3, 10, 17, 24.

The Third Course will be by Mr. W. H. Preece, on "Recent Advances on Telegraphy." It will consist of Five Lectures, to be given on the following dates:—

April 21, 28, May 5, 12, 19.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. W. Mattieu Williams, "Mathematical Instruments." (Lecture V.)
Royal United Service Institution, Whitehall-yard, 8½ p.m. Druitt Halpin, "An Economical Means of Raising Ironclads sunk in Deep Water."
Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. Resumed discussion on Mr. Hedley's papers, "The Rating of Railways," and "Cartage and Station Terminals."
Medical, 11, Chandos-street, W., 8.30 p.m.
Asiatic, 22, Albemarle-street, W., 3 p.m.
Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. 1. Mr. I. P. Thompson, "The Argument from Design considered." 2. Rev. E. Duke, "Genesis and Geology."
London Institution, Finsbury-circus, E.C., 5 p.m. Dr. B. W. Richardson, "Health and Recreation." (Lecture I.)

Tues. ...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (African Section.) Mr. B. Francis Cobb, "Retrospect and Prospect in Egypt."
Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture II.)
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. R. C. Patterson, "The Railway System of South Australia."
Statistical, Somerset-house-terrace, Strand, W.C., 7¾ p.m. Mr. R. Giffen, "The Fall of Prices of Commodities in Recent Years."
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m.
Royal Colonial, the "Pall Mall," 14, Regent-street, S.W., 8 p.m. Mr. Caldwell Ashworth, "Canada: its Progress and Development."

Wed. ...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. Henry Dunning Macleod, "The Modern Science of Economics."
Geological, Burlington-house, W., 8. p.m. 1. Mr. Frank Rutley, "Community of Structure in Rocks of Dissimilar Origin." 2. Mr. A. Murray, "Distribution of the Serpentine and Associated Rocks, with their Metallic Ores, in Newfoundland." 3. Mr. H. S. Poole, "The Gold-leads of Nova Scotia."
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Capt. R. F. Burton, "The Oghani Inscriptions, and the Mushhajjar Characters."

Thur....Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 7 p.m. Prof. J. Rolleston, "The Fauna and Flora of Prehistoric Periods."
Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. H. Gordon, "Electric Induction." (Lecture II.)
Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.
Royal Society Club, Willis's-rooms, St. James's, S.W., 6 p.m.

Fri.......Royal United Service Institution, Whitehall-yard, 3 p.m. Vice-Admiral G. G. Randolph, "The Relative Importance of Broadside and End-on Fire from Ships of War Tactically Considered."
Royal Institution, Albemarle-street, W., 8 p.m., Weekly Meeting. 9 p.m., Prof. W. E. Ayrton, "The Mirror of Japan and its Magic Qualities."
Quekett Microscopical Club, University College, W.C., 8 p.m. 1. Mr. F. A. Bedwell, "The Urticating Threads of *Actinia Parasitica*." Mr. E. T. Newton, "A New Method of Preparing a Dissected Model of an Insect's Brain from Microscopic Sections."
Clinical, 53, Berners-street, W., 8½ p.m.

Sat. ...Physical, Science Schools, South Kensington, S.W., 3 p.m.
Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Seeley, "Reptilian Life." (Lecture II.)

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,366. VOL. XXVII.

FRIDAY, JANUARY 24, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

DEATH OF H.R.H. THE PRINCESS ALICE.

The following Address of Condolence was forwarded, through the Right Honourable Richard Assheton Cross, M.P., Secretary of State for the Home Department, to Her Majesty the Queen:—

"The Council of the Society of Arts desire to convey to Her Majesty the Queen the expression of their heartfelt sympathy and condolence on the occasion of the sad loss Her Majesty has sustained by the death of her beloved daughter, Her Royal Highness the Princess Alice of Great Britain, Grand Duchess of Hesse Darmstadt, whose bright example, as a daughter, sister, wife, and mother, will ever remain in the memories of all who live to labour for the happiness and improvement of mankind."

The following reply has been received from the Home Secretary:—

Home-office, Whitehall,
15th January, 1879.

SIR,—I have had the honour to lay before the Queen the loyal and dutiful address of the Council of the Society of Arts, Manufactures, and Commerce, on the occasion of the death of Her Royal Highness the Grand Duchess of Hesse, Princess Alice of Great Britain and Ireland, and I have the satisfaction to inform you that Her Majesty was pleased to receive the same very graciously.

I am, Sir,
Your obedient servant,
(Signed) RICHARD ASSHETON CROSS.

P. Le Neve Foster, Esq.,
Secretary to the Society of Arts,
Adelphi, W.C.

SWINEY PRIZE.

A meeting of the adjudicators of this prize, appointed by the will of the late Dr. Swiney, was held on January 20th, 1879, at the Rooms of the Society of Arts, Lord ALFRED CHURCHILL in the chair.

The SECRETARY read the advertisement convening the meeting.

The SECRETARY read the following minute of the Joint Committee of the Society of Arts and the College of Physicians:—

The Joint Committee of the Society of Arts and the Royal College of Physicians recommend that the award of the Cup and Coin, in conformity with the provisions of the late Dr. Swiney, be made in favour of Norman Chevers, M.D., the author of a published work on jurisprudence, entitled "A Manual of Medical Jurisprudence for India."

ALFRED S. CHURCHILL,
Chairman.

It was thereupon moved by the CHAIRMAN, seconded by Mr. ANDREW CASSELS, and resolved, "That the prize, a Silver Goblet, value £100, containing gold coin to the same amount, be adjudged, and the same is hereby presented, to Norman Chevers, M.D., the author of a published work on jurisprudence, entitled 'A Manual of Medical Jurisprudence for India.'"

A vote of thanks to the Chairman was proposed by Dr. HENRY PITMAN, seconded by Mr. J. A. YOUL, C.M.G., and carried unanimously.

The cup has been executed by Messrs. Garrard, from a design made expressly for the Society by the late Daniel Maclise, R.A.

INDIAN SECTION.

Friday, January 17th, 1879; Col. H. YULE, C.B., R.E., in the chair.

The paper read was—

AFGHANISTAN.

By C. E. D. Black.

In considering the geography of any integral portion of the continent of Asia, our attention naturally reverts to that central converging point with which the physical structure of each of its individual countries appears to be more or less immediately connected. From the Pamir plateau—that bleak and lofty region, so full of interest both to the historian and to the geographer, and yet so imperfectly known even to the restless enterprise of modern science—there diverge five of the mightiest mountain ranges of the world, which, radiating over the expanse of the great Euro-Asiatic Continent, extend with scarce a break from the shores of the Atlantic to the Pacific, and from the Arabian and Indian Oceans to the Siberian Polar Sea. Of these mountain ranges, the oldest, geologically speaking, though, as far as we know, not the

loftiest, is the Kuen-Lun, which forms the northern escarpment of the massive Tibetan plateau, and which, continued to the west under the name of Hindu Kush, and Paropamisus, plays a similar part in reference to the eastern part of the Iranian plateau, including Afghanistan.

In speaking of Afghanistan, I am aware that it may seem presumptuous in one who has never set foot in the country to attempt to treat of it. But inasmuch as it seldom falls to one man's lot to visit all parts of a country, and further, as some of the ablest geographical compilations of our time are well known to have proceeded from the pen of those who have confined themselves to a thoughtful examination of the accounts of travellers, I feel that there is at all events good precedent for the course I have pursued. This paper does not pretend by any means to be a complete synopsis of our existing knowledge of Afghanistan. Such a task would prove herculean, for the mass of existing information would effectually prevent adequate condensation within restricted limits. But it may be of some service to draw attention to the chief natural features and resources of a country which is certainly destined to have an important bearing on the future policy of India.

The Hindu Kush range, of which we have already spoken, and its western extensions, often called by the classic title of Paropamisus, form a species of backbone from which springs a network of minor mountain ranges and spurs which spread over the whole face of the country. Between these spurs, which in most cases are exceedingly bleak and bare, lie a series of elevated flat-bottomed valleys, with cultivation in the vicinity of the streams. On every side except the north-east the irregular highlands forming the country of Afghanistan slope down to a considerably lower level, and the rivers draining in those directions get absorbed in a belt of country of a sandy or semi-desert character. Here, the desolation of the desert is brought face to face with the beneficent influence of the mountain range, and where the effect of the latter merges in the former we find cultivation arrested as well as the extension of habitation and the general well-being of the country. This description of things specially applies to the districts south and south-west of the Oxus, from the west of Herat to the Seistan Lake, and from the southern extremity of the latter to Shal or Quettah. The Murghab and Tejend are lost in sandy deserts. The Farrehrud, Kashrud, and Helmand, descending from the mountains and passing between sterile waste to the Seistan Lake, resemble the river system of Chinese Tartary, struggling on from surrounding ranges to the central reservoir of Lob-Nor. The Arghundab and Turnuk are consumed in irrigation before reaching the Helmand, precisely as are the rivers of Balkh and Saripul on the left bank of the Oxus and the Zerafshan on the right. Turning our attention to the principal ranges of Afghanistan, we observe that from the Hindu Kush a ridge, forming the water parting between Ghuzni and Cabul basins, juts out and merges in the Sufeid-Koh or White Mountain, an important range which forms the southern water-shed of the Cabul basin. About the point where the Shutar-gardan or Camel's Neck pass is situated, there springs a range, the existence of which, though not absolutely confirmed, has been set forth with great plausibility, first, as I believe, by Colonel MacGregor, and since elaborated by Mr. Clements Markham in a very interesting paper on the mountain passes on the Afghan frontier of British India, which you will find in the recently published "Proceedings" of the Royal Geographical Society. This range, which although not explored continuously has been proved to exist at certain detached points, forms the water parting between the western tributaries of the Indus and the streams which converge into the inland basins of Afghanistan. Mr. Markham has drawn attention to the similarity between the system of the Himalayas and that of the Sulimanis, which we are now considering, in that they both consist of an inner chain, on the slopes of which there rise rivers which burst through the outer chain, and roll their waters into the plains. This inner or western Sulimani range appears to split into minor spurs about the latitude of the Kand Peak, and then to run to the Sar-i-Bolan ridge, whence rising again, it merges south into the table land of Khelat, and is finally lost in the sea, or the deserts of Makran.

The Sufeid-Koh itself, rising out of the high table land which separates the Cabul and Ghuzni basins, follows the 34th parallel of latitude for about a hundred miles, then sends one arm to the north-east, terminating on the Cabul river, which flows round its base in a great curve, while the main range continues eastward to the Indus, between Kohat and Peshawur. Northward of the Sufeid-Koh there is a mass of mountains which are held by some authorities to be a continuation of the great Himalayan system. Our present knowledge, both topographical and geological, of these mountains appears, however, to be too slender to admit of this theory being unhesitatingly accepted. Omitting any detailed notice of the spurs which jut out from the Hindu Kush, north and south, into the valleys of the Oxus and Cabul river, we may content ourselves with observing that the other principal ranges of Afghanistan are the Koh-i-baba, which is really an oblique continuation of the Hindu Kush, and which throws off three ranges, running east and west, called respectively Siah-Koh, Sufeid-Koh, and Tirband-i-Turkestan. Besides these, an important spur, called the Paghman range, divides the basins of the Cabul and Helmand rivers, while others divide the courses of the Argandad, Turnuk, and Arghesan rivers.

Taking the physical aspect of the country as a whole, and bearing in mind its co-relation to other similarly situated countries, we note that "throughout the whole region of Central Asia there is a triple division of territory which naturally produces a triple division of population, firstly, those in the mountain region, with its invigorating climate, its vast upland downs, well suited for summer pasturage, and its rocky ravines carrying foaming torrents to the plains; here dwells a hardy peasantry—descendants in some cases of the primitive inhabitants, but more often intermingled with offshoots of the many migratory races who have since swept through the country. At the foot of the mountains again are tracts of surpassing fertility, with well-watered plains, where the great mass of the population congregate in towns and villages, and pursue the

peaceful arts of life; and thirdly, beyond the cultivated plain stretches out in every direction the pathless desert, which has been tenanted by pastoral nomads ever since the earth was peopled. Here rapine and disorder seem to have their natural home, and here, at the present day, to the ordinary excesses of brigandage is superadded the detested occupation of man-stealing."*

The truth of this picture will be recognised as we proceed to notice in succession the natural divisions of Afghanistan. Commencing from the north-east extremity, we notice first that region, the drainage of which converges into the Cabul river and that of the Indus. This basin is enclosed by the Sufeid-Koh, the Paghman, and Hindu Kush ranges, and is drained by a variety of streams descending from those various ranges. The most important valley deserving of notice is that of the Indus, where that mighty stream flows through territory beyond the limits of British India. It is only in the larger geographical sense that Afghanistan can be said to approach this and its closely adjacent valleys, which have lately been explored for the first time by the Mullah, one of that useful band of native travellers, whom Colonel Walker, the present Surveyor-General, and the late Colonel Montgomerie, have trained, with such excellent results, to explore the countries adjoining our Indian frontiers.

Here the great river traverses a distance of upwards of two hundred miles, as it descends from a height of about 5,000 to 1,200 feet above sea level. It winds its way tortuously through great mountain ranges, whose peaks are rarely less than 15,000 feet in height, and culminate in that majestic peak, Nanga Parbat, whose height is exceeded only by a very few of the Himalayas. The river, in many places, is hemmed in so closely by these great ranges, that its valley is but a deep-cut narrow gorge, and, as a rule, there is more of open space and culturable land in the lateral valleys, which nestle between the spurs of the incompassing ranges. Very difficult of access from all quarters, this valley is inhabited by a number of hill tribes, each independent and suspicious of each other. Each community is independent, elects its own rulers, has little intercourse with its neighbours, and communicates only with the outer world through the medium of a few individuals who have the privilege of travelling through the country as traders, a privilege fortunately possessed by Colonel Walker's *employé*, who has been the first to map out for us this region.

The valley of the Swat river, between the Kunar and the Indus, is still quite unexplored. It lies in a sheltered position, being surrounded by lofty snow-clad mountains, but is unhealthy in summer, owing to the extensive surface under rice cultivation. It is altogether highly cultivated and thickly populated by an independent Muhammadan people which, until recently, was under the general control of a spiritual ruler, called the Akhund, who, on most occasions, was well disposed towards our Government, and endeavoured to prevent his turbulent people from coming into collision with our subjects. Since his death we have had but little information regarding the inhabitants of this secluded valley.

Of the valley of the Kunar river which joins the Cabul river below Jellalabad, we have been supplied with an interesting account by the Mullah, one of the native explorers attached to the Indian Survey Department, who travelled through it in the year 1873-74. The limit of Afghan territory is at a place called Maroara, beyond which are independent States, the most powerful of which is Chitral. Recent reports state Chitral to have been annexed by the forces of the Maharajah of Kashmir. The importance of such an annexation lies not so much in the natural resources of the territory, which consist of little else beyond excellent timber, as in the fact that a trade route leads here into the valley of the Oxus, by a way which is considered to be the lowest depression over the great Hindu Kush range, and to which attention has often been called of late years as a route of possibly real moment, whether as a military or a commercial access from Central Asia to India. There is no evidence that it was ever used as either one or the other.

Of Kafaristan, that interesting region situated between Panjsher and Kohistan on the west, and the valley of the Chitral, or Kunar river on the west, we have but a vague knowledge, as no European is known to have penetrated into it. The country is believed to be throughout of a mountainous character, and to afford but little scope for cultivation, which is chiefly carried on in the sheltered valleys to the south. The slopes and ravines of Hindu Kush, as well as many of the lower ranges of hills, are generally covered with primeval forests, containing trees of immense size. Indeed, there is little doubt that there is a great natural wealth of timber in the country, but the extreme difficulty of the communications, which consist of mere footpaths intersected here and there by frightful ravines, yawning chasms, and foaming torrents, crossed by primitive rope-bridges, made from goats' hair, makes commercial intercourse well-nigh an impossibility. The inhabitants, who are known by the name of Kafar Siahposh, are a race to which considerable interest attaches itself, in consequence of their supposed physical similarity to Europeans, their respect for the sacred obligations of hospitality, and the faith with which they observe all compacts even with the Muhammadan neighbours, towards whom they bear an inveterate hostility. Of their origin we know nothing, though several bold theories have been propounded to ascribe to them European descent. They themselves, indeed, sent a special deputation to claim brotherhood with the Englishmen who spent part of the winter of 1839 in Jellalabad, and it is much to be regretted that so favourable an opportunity of becoming acquainted with the country and the people was unfortunately missed.

The Surveyor-General of India has, however, I understand, given special directions to his surveyors with the northern column of the Afghanistan forces to seize the first suitable opportunity that may present itself for visiting and exploring Kafaristan.

Leaving the northern watershed of the Cabul river, and turning our attention to the main stream itself, it is noticeable that a natural break occurs

* Rawlinson's "England and Russia in the East."

in the character of the valley through which it flows, between Gandamak and Jellalabad, the difference in the elevation of which is upwards of 2,600 feet. This break or descent marks the transition to an almost different climate, and the Emperor Baber, whose autobiography proves him to have been so accurate an observer, did not fail to mark it. His words are:—"The moment you descend you are in another world. The timber is different; its grains are of another sort; its animals are of a different species; and the manners and customs of the inhabitants of a different kind." In the upper part of the basin, about Cabul, the snow lies for three months on the ground in the winter, while in Jellalabad the surrounding valley teems with cultivated products of an Indian or tropical type, and the winter is delightful.

Cabul itself, situated almost at the gorge of the principal passes leading from India to Turkistan, has always been a place of exceptional commercial importance, though internal troubles, and the devastating hordes of conquering invaders, have checked any peaceable and material development of the resources of the surrounding district.

The lower part of the Cabul valley has recently been brought prominently before us in connection with the advance of Sir Samuel Browne's expeditionary force. Beyond the Khaibar, Tartara, and Abkhana routes, by which access is opened from the plains of India to the highlands of the west, the road to Cabul leads on towards various passes and defiles over the spurs of the Sufeid-Koh range, that over the Karkatcha range attaining a height of 8,000 feet. In 1842 the passage of these defiles proved utterly disastrous to the retreating division of the British forces, and there can be no doubt that in the hands of a strong and determined foe, such positions might render Cabul almost unapproachable from the side of India.

South of the Sufeid-Koh range lies the Kurram valley, the head-waters of whose river descend the junction of the western or inner Suliman range with the Sufeid-Koh, afterwards augmented by subsidiary streams from the adjacent Mangal country, and the valleys of Furmul, Khost, and Dawar. The Kurram valley, along which lies the direct route from Bannu, in British India, to Ghuzni, has been for centuries one of the most important routes across the Sulimani mountains. The valley is very beautiful, being profusely cultivated in the vicinity of the stream, whence irrigating canals are derived and water the rice fields on either side. In the upper part of the valley dwell the Mangals and Jajis, and lower down the Turis, tribes of which we have heard a good deal of lately from the camp of General Roberts. The route through the Kurram valley, in spite of the obstruction of the Pewar Pass, and the still greater difficulties of the lofty Shutar-gardan beyond, is, perhaps, the best of all the roads between Afghanistan and the Punjab, both on account of the comparative easiness of the greater part of the road, and the abundance of water, fuel, grazing, and supplies that are procurable in it.

From the southern extremity of the Kurram basin to the peak of Takht-i-Suliman is the country of Waziristan, and here the eastern or outer Sulimani range is developed into a system of lofty mountains with several parallel ridges, pierced at intervals by streams rising on highlands to the westward, which although but rivulets or dry water-courses in winter, are swollen to an astonishing degree by the melting of the snow. The Waziris are a powerful tribe, numbering about 44,000 fighting men.

An important route from Dera Ismail Khan and the valley of the Indus to Ghuzni and Kandahar lies up the valley of the Gomul river, a stream which drains a most extensive area of country, being reinforced by the waters of the Zhob river, which rises full 150 miles to the south. This is, perhaps, the chief trade route between India and Central Asia, and along it for centuries past has travelled a clan of soldier merchants called Povindahs, or runners, who, in the face of incredible difficulties arising from the continual exactions levied from them at every turn, bring to India fruits of various sorts in great profusion, saffron, madder, silk cloths, carpets, saddlery, horses and other animals in exchange for cotton goods, crockery and metal ware, indigo, brocades, drugs, and many other miscellaneous articles which they convey to Afghanistan and even to distant Bokhara.

An excellent and picturesque description of the camp life of the Lohani Povindahs is supplied by Mr. Vigne in his interesting volume of travels to Jhuzni, Cabul, and Afghanistan.

The caravans, or kafilas, start from Derabund, a village situated on the eastern slopes of the Suliman Mountains, in April and May, and return about October. They bring from Cabul, pomegranates, almonds, and raisins; from Bokhara, horses, cochineal, nankin, gold, thread, raw silk, and other goods; from India they bring kimcab or golden cloth of Benares, English chintzes, and calicoes, gun locks, and similar articles.

The kafila, starting before daylight, is preceded by a few straggling matchlock men, and a drummer to beat the alarm. Then follow the numerous camels, laden and unladen; the ladies, clad in chocolate coloured robes trimmed with yellow, ride upon a kind of square platform composed of numerous cushions placed upon the camels, which in their turn are profusely decorated with cowrie shells. Some of the ladies are exceedingly handsome, usually very fair, with regular features, black hair, hazel eyes, and blackened eyelids. The young girls wear a single braid in front, which supports a piece of gold, a coin, or other ornament dangling between the eyes; the married women wear massive gold earrings, composed of thin plates strung together. The cavaliers prance along gallantly by the side of their ladies, and herds of cattle, of the half-bred humped breed, light, active, and not easily fatigued by wading through streams, or clambering over rocks, are driven along, mingled with goats and sheep.

On arriving at the camping ground the camels were unladen with marvellous celerity; the burdens were piled up like a wall on the western side of the tent in the direction of the prophet's tomb at Mecca. A short meal and a long siesta ensued, and for three or four hours the whole camp was hushed till the afternoon, when everyone awoke; the camels were driven in by the watchmen, the men seated themselves in groups to smoke and chat, the women gossiped from tent to tent, and the children

enjoyed the inexpressible pleasure of making a noise. The evening meal was then prepared, and the tents struck before they retired to rest, so that there might be no delay in the morning. The guards loudly challenged throughout the whole of the night, firing their matchlocks whenever they thought prowlers were at hand. The next morning, not more than a quarter of an hour elapsed between the commencement of the bustle and the general move forward."

The depredations and molestations to which these itinerant merchants are exposed are so serious, that they never think of moving except in large armed bodies. Owing, as it is said, to a refusal in times past of the Lohani Povindahs to pay permit money while traversing the Waziri country, a deadly feud has sprung up between the Waziris and the merchants, and the progress of the latter through the defiles of the Sulimani range seldom takes place without a skirmish, if not a pitched battle between the two tribes. Notwithstanding these tremendous discouragements, the trade of the Povindahs by the Khaibar, Tartara, Kurram, Gomul, and Bolan routes in 1874 was estimated at a value of not less than a million and a half. Under proper measures of protection and encouragement, it would be capable of almost indefinite expansion.

South of the Gomul river there is an enormous highland area which is entirely unexplored, but of which a better knowledge is extremely desirable. We are frequently told that there is no route between Afghanistan and India adapted for the passage of an army, with the exception of the Khaibar, the Kurram, the Gomul, and the Bolan passes. But, as a matter of fact, the number of passes leading from the plateau of Afghanistan into the valley of the Indus is more like fifty than five, and before we can safely undertake the very difficult task of proving a negative, it behoves us to learn something more about all these various passes and their western exits. Major Raverty tells us that in 1653 A.D. Prince Dara Shukoh advanced at the head of an army of 104,000 by way of the Sangar pass (about 50 miles north of Dera Ghazi Khan), that this pass can be made practicable for moderately heavy guns, and that by it Kandahar is brought upwards of 100 miles nearer to the Indus River than by way of the Bolan. I have ventured to bring the importance of exploring this route to the notice of an energetic surveyor and able geographer now with General Stewart's column, and I have hopes that he will be enabled to investigate it.

The lofty plateau on the western side of the water parting drains to the north, into Lake Abistadeh, a shallow sheet of water, about seventeen miles long by fifteen in breadth. This plateau, as far north as the Cabul river, is inhabited by the Ghilzai tribe, who offered the fiercest opposition to us in the last campaign, but whom recent accounts report as well-disposed towards us.

To the south-west the face of the country gradually slopes down to an almost impassable desert, which separates Western Afghanistan from Beluchistan. Part of the drainage of the southern part of the plateau above referred to, is carried off by the Lora river, which discharges its waters in a hamun or marshy lake south of the Helmand river. The streams northward of the Lora converge into the Helmand, which again loses itself in the famous Lake of Seistan, a huge swamp of varying extent on the western confines of Afghanistan.

The Helmand is the most important river between the Indus and Tigris. Rising in the Koh-i-baba it flows in a south-westerly direction through the Hazara country, in a deep gorge, for 260 miles, its banks fringed with rose bushes and osiers. Above Girishk the river is said to be much obstructed by enormous boulders, but at a point close to where the road from Kandahar to Herat crosses the river by means of a ford, it enters a flat region, and begins to flow over a sandy and gravelly bed with a less confined channel. Its total course, which is still very imperfectly known, especially in its upper half, is estimated at 740 miles. To the westward the discharge is effected by three streams, all with independent courses to the Seistan lake, and on the east the Turnuk, Arghasan, and Dori unite with the Arghundab, the principal tributary of the Helmand.

The most important route in Western Afghanistan is that which crosses the Helmand, at the ford of Girishk, and which connects Kandahar with Herat, for, in the event of an invasion of India from the north-west, this, in the opinion of the highest authorities, would be the route selected for the main line of advance. It has been pointed out also that Kandahar, which is situated in a level and cultivated plain, would form a strong point of concentration for our forces, and that by its occupation Kabul would be cut off from communication with Herat. This contention I would submit leaves out of consideration the possibility of direct communication between Herat and Kabul by way of the Hazara country, a route which was covered in 12 days by Shah Zuman with a body of horse, and which has been traversed in as short a time as eight days. According to Burnes, caravans make use of this route in summer, though on account of the numerous hills, those by Maimana or Kandahar are usually preferred. Still, when we consider how slight an application of engineering science often serves in these days to transform roads of proverbially bad character into practicable, if not easy means of communication, it will be conceded that this route deserves at least to be carefully explored.

The Hazara country consists of a highly elevated table-land lying about the Paropamisan ranges. It is almost unknown to us, though it has been traversed at detached points by General Ferrier, Captain Arthur Conolly, and a few other travellers. Conolly traversed the eastern Hazarah country while journeying from Bamian to Maimana, and describes a most remarkable defile between perpendicular limestone mountains called the Deriah-i-Khurgosh or "Hare's defile," by which (as it would appear) he crossed the Tirband-i-Turkistan range. I have never yet seen Captain Arthur Conolly's route laid down on any map. The Hazarah country is excessively cold in winter, and unproductive as far as regards vegetation, though lead, copper, lapislazuli, and sulphur abound. The inhabitants are distinctly of a Tartar type, having small eyes, high cheek bones, and flattened noses, and are said to have sprung from fragments of those Tartar tribes who accompanied Timur Leng

and Jinghiz Khan, and other invaders, in their expeditions. This is no doubt true in fact, though it is probable that a part also represent the oldest races of the hill country.

We now come to Herat, which is situated in the fertile and well watered valley of the Heri Rud river, which, like the Murghab, discharges its waters in the desert to the north. It is a city of extreme importance, for it is said to be of more trade than any other in Central Asia. Hither repair merchants from Persia, who come by way of Meshed, others who come from Bokhara and Khokand by way of Merv, and others from Hindostan and Kandahar. Besides being a mart or emporium for the goods brought from these distant countries, it produces silk, saffron, assafœtida, which is exported largely to Hindostan, carpets of exceptional softness and brilliancy, and horses, which at the time of Captain Christie's visit, in 1810, used to fetch occasionally, as much as £500 a-piece. Such is the fertility of the valley, that it is capable of affording supplies to 150,000 men, while the inhabitants possess 12,000 bullocks for agricultural purposes. It scarcely needs pointing out that the future of Herat must always have a most vital bearing on the policy of Afghanistan.

I do not propose in the present paper to touch on the province or dependencies of Afghan Turkistan, which is the name applied to the congeries of sub-provinces extending south of the Oxus from Wakhan to Maimana. These, though subject to Afghan rule, are divided from what may be termed Afghanistan proper by a stupendous mountain barrier which, though pierced by some score of passes, has ever proved to be the most formidable obstacle to the invading hordes which have from time to time poured down from the north on to the plains of India. It also forms the water parting between the basin of the Indus and that of the Oxus, soon probably to become a highway of Russian trade, and therefore forms an appropriate limit to a paper which professes to treat of Afghanistan from an Indian standpoint. I cannot, however, close these observations without reference to the resources of Afghanistan, and to some points to which our future attention may be usefully directed.

It has been the fashion in some quarters to speak of Afghanistan as an excessively poor country. This statement, I venture to think, is scarcely warranted. It is impossible for any one to read many of the records of travel through Afghanistan without being struck with the remarkable evidence of mineral wealth which constantly occurs. Silver, gold, iron, lead, copper, antimony, sulphur, nitre, and coal, all abound, and very few of these are worked, owing to the want of energy and skill in the people, the unsettled state of the country, and also to a peculiar superstitious dread they have of penetrating into the bowels of the earth. There can be no doubt that a careful geological survey of the country would lead to the discovery of very considerable mineral resources. Silk is produced largely, and its manufacture is said to be capable of great improvement, while there is an almost unlimited supply of wool of a superior quality to be obtained, the extent of pasture land having been estimated by Burnes at about four-fifths of the whole area of the country. "Postins," or sheep-skin pelisses, form an important article of exports, as well as "Chogas," or cloaks made of camel's hair cloth or the wool. An increasing trade is also done in the export of raw wool.

Under a system of trade registration which is, as yet, confessedly tentative, the imports from Afghanistan into the Punjab, as noted at various frontier posts, amounted to £741,000 in the year 1876-77. The chief items were fruits and nuts, silk, drugs, dyes, timber, and wool. The exports during the same period amounted to £817,123 in value, and comprised tea, piece goods, indigo, leather, and sugar. The export of tea from the Punjab into Afghanistan has shown a very remarkable increase during the last three years, and may not improbably be ascribed to the increased outturn and improved quality of the Indian tea, which is now finding increased favour in so many quarters.

These figures, however, can be but a feeble evidence of the trade which would infallibly spring up were tranquility ensured by a stable Government. That remarkable branch of trade carried on by the Povindah merchants, would increase greatly were the extraordinary difficulties which now beset them but removed. It will, I think, be conceded that arguments based on the supposed poverty of the country are, to say the least, not convincing.

There is one lesson, among others, which recent events have forced upon our attention, and that is, the utter imperfection of our present knowledge of Afghanistan. It is impossible for anyone to examine the recent elaborate map prepared by Major Wilson, late of the Ordnance Survey Office, Dublin, without being struck by the enormous areas of country of which we know positively nothing, and as the topographical examination of a country naturally precedes every other branch of statistical inquiry, it is not difficult to realise what extensive gaps there must be in our general knowledge of the country and all that is in it. Nor is this all. The knowledge for which materials exist cannot be said to be made properly available. I do not wish to underrate the extraordinary diligence and research displayed by Colonel MacGregor, C.S.I., in the compilation of his "Gazetteer," which, though not published to the world at large, has long been known to Indian officials as the most invaluable work of reference on the subject of Afghanistan. But this represents an isolated effort, due to no planned organisation, but to the diligence of an individual officer.

Our present and future relations with Afghanistan demand, therefore, that so excellent a beginning should be properly continued, and for the due performance of this a special agency is absolutely needed. A small department has been established within the last few years for the collection of statistical information regarding India, for eventual publication in the shape of an Imperial Gazeteer. I venture to think that the establishment of a dependent or similar department, which shall be charged with the accumulation of statistical information of every description regarding the countries immediately adjoining India, would prove of undeniable utility in all our military, political, and commercial dealings with those countries. This is not a work which can be as well performed by the Quartermaster-General's Department, the

Foreign or the Survey Department, for it belongs to neither of the three in particular, but all three would benefit by its existence, and would contribute towards its efficiency. Reports furnished by British officers, by native emissaries, by traders, by intelligent travellers of all sorts, might be diligently collected, and collated with all existing data. The result would be that there would be a recognised nucleus for all trans-frontier information, which, for want of such a central repository, is now too often scattered in different offices, pigeon-holed, or altogether lost. In competent hands the information would be ably examined, sorted, co-ordinated, and made available for future reference. The real blanks in our knowledge would stand out more clear, and adequate means for their removal could be taken. We have an excellent body of surveyors in India who combine zeal and devotion with the highest professional knowledge, and who, if permission were but granted to them, would collect statistical information regarding these frontier States as safely and as rapidly as do the Russians on their side of the Oxus. These fresh stores of information acquired would certainly add to the general well-being of the various nationalities on both sides of the British frontier, and would enable our rulers confidently to grapple with difficulties which harrass and retard the progress and prosperity of the empire.

DISCUSSION.

The Chairman, in inviting discussion, reminded the meeting that in that Society they were bound by the principle of the "Needy knife grinder," who never meddled with politics. A few years ago it would have been a strange thing to mention that rule in connection with a geographical subject, but somehow or other Afghanistan had become so redolent of political feeling, that it was necessary to recall this to the recollection of the meeting.

General the Hon. Sir Alexander Gordon, K.C.B., M.P., said the paper was a most interesting one, but he had been disappointed at not getting any information with regard to the western part of Afghanistan. There were many interesting details given as to the eastern part, but considering the question which was now before the public, of what was to become of Afghanistan, the western side appeared more important. Any one who studied Major Wilson's map would see that a great portion of the western side was a desert salt plain, or barren steppe, and when people talked of this country being invaded by Russia or any other power, they should bear in mind the extreme difficulty, if not impossibility, of moving across these desert plains. This point seemed to have been too much lost sight of. The great River Helmund, which received all the waters from the mountains between Herat and Kandahar, actually lost itself in the desert. That did not indicate a very fertile country.

Maj.-General Sir Arnold Kemball, K.C.S.I., C.B., did not think there was much to say in the way of discussion, as all political questions were forbidden. If the western part of the country were as barren as had just been represented, he did not understand how invasion could ever have been made from that side.

The Chairman thought Sir Alexander Gordon had taken for granted that the blank spaces on Major Wilson's maps represented steppes, or deserts, but the fact was, they only represented deserts in his information; it was a conscientious map, in which nothing was put down except what had been actually surveyed.

Sir Alexander Gordon said he did not allude merely to blank spaces on the map, but to what was marked distinctly "Great Desert," "Sandy Plain," and so on. This appeared not only in Major Wilson's, but in other maps, such as the Russian maps and the maps of the Quartermaster-General of India.

Col. Malleson, in reply to the observations of Sir Alexander Gordon, wished to remark that armies had invaded India, or come to Kandahar, across these deserts; and that repeatedly. It was done by Nadir Shah, at the head of a hundred thousand men; and, if he could do it, he did not see why it should not be done in the present day, when the facilities for movement of large bodies of men were so much greater. There was nothing in the state of the western frontier of Afghanistan, and the condition of the countries lying between it and the capital of Persia, which prevented the invasion of Persia by the Afghan King of Kandahar 150 years ago; and that invasion was not an isolated one. It occurred twice, and terminated in the conquest of Persia by the Afghan ruler of Kandahar. Subsequently, the tables were turned, and, across those deserts which the gallant General seemed to think were pathless, the armies of Nadir Shah moved without encountering any difficulty or opposition. What had been done once, could always be done again.

Mr. Trelawney Saunders thought Sir Alexander Gordon was mistaken in supposing that the whole country which would have to be traversed by an army coming from the west was a desert. So far from that, he begged to say that from the plateau of Armenia to the plains of India, along the south side of the Caspian, and the southern edge of the desert of Turkhistan, there was a range of upland, and the whole of the upland, from its northern escarpment rising from the desert of Turkestan and the River Oxus, spread away in fertile valleys, most of them running east and west, and highly favouring communication in the direction of east and west. It was, therefore, no wonder that from the time of Alexander the Great these regions had been repeatedly traversed by armies. In fact you could hardly have a country more favourable for the passage of armies than that which lies between the mountains of Armenia and the plains of India. It was well watered, and had large towns at intervals, and population all along the route. Under an ordinarily good Government no part of the face of the earth would be more prosperous or more capable of producing supplies.

Colonel J. B. Hardy having himself travelled from the south shore of the Caspian to Herat, *viâ* Meshed, thought the last speaker was slightly mistaken. He had gone by that route, and back again to Bostan, *viâ* Khaf and Turshiz, and a great part of that country was undoubtedly a desert, where they had travelled for several days together without meeting any inhabitants whatever, or seeing villages of any kind. In fact, they had to carry provisions and water with them for the most part of the way. There were scarcely any routes which could be called thickly populated or covered with towns. No doubt there were a few villages and important towns between the south east corner of the Caspian and Meshed, but the population had almost disappeared, and you might travel for days by the Fraelt and Ferrier routes without meeting anyone but members of other caravans. The population of the tract of country southward from Astrabad, had decreased in the most marvellous manner within the last century, for there were remains of watercourses and irrigation works where there was now an absolute desert. Travellers underwent, under the most favourable circumstances, great privations at times. There were caravansaries every 20 or 30 miles, but in a ruined condition, and containing no regular supplies. The only large towns on the routes that he had travelled, were Bostan, Nishapur, Meshed, Ghorian, Khaf, and Turshiz, but between these places there were scarcely any villages worthy the name, and an army of

even 10,000 men would have to carry their provisions with them. Persian troops, who march from Meshed to Teheran and back, have great hardships to undergo; in 1857 and 1858, they were frequently starving for want of provisions, and died by scores. Therefore, although the difficulties of the route might be exaggerated, they were certainly very great.

Sir Arnold Kemball asked if Colonel Hardy was not simply alluding to the desert of Khorassan. He did not seem to have travelled by the valley of the Attrek.

Major Bateman-Champain, having been a good deal at Ispahan and Teheran, said he had always heard that the route ordinarily traversed by pilgrims was, practically speak-ing, a desert as described by Colonel Hardy.

Mr. Boulger said the real line of route from the south-east corner of the Caspian was that followed by M. Vambery, through Bujnurd to Meshed, which skirted the southern slopes of the mountains of Khorassan. This region was then fertile, with villages at short distances. Sir John McNeil, in his letter to Lord Palmerston, 1838, made the observation that the route was perfectly feasible for a large army, that not only was there a good road and plenty of water, but there were spots along the route where an army of 50,000 could be encamped and remain for a considerable time, and that he had every reason to believe that the route from Herat to Kandahar was not more difficult, although he could not speak from personal observation. M. Ferrier, who travelled twice between Meshed, Herat, and Kandahar, encountered considerable difficulties, but they were not insurmountable, and mentioned one spot at least—the Herat valley — where an army could receive large supplies.

Sir Alexander Gordon asked if Mr. Boulger had read the report lately laid before Parliament of the expedition which the Russians formed to march from the southern corner of the Caspian up the valley of the Atrek. The account they gave of the march showed there were very great difficulties, and very little supplies or even water to be had.

Mr. Boulger said that column started from the Russian post of Chikishlair, not the south-east corner of the Caspian.

Sir Alexander Gordon said it probably started from that part of the Caspian which was considered most advantageous.

Mr. Boulger—But it was only intended as a move against the Turcomans, and not as an advance on Herat.

The Chairman said it was evident that the subject did not allow of very much discussion under the limitation which he was obliged to impose upon it; it was very unfortunate that this necessity had been laid upon them by the circumstances of the time, and also that the author of the paper was not present, as he might have given some further information on the points which had arisen. There was only one point in the history of the country which he might perhaps mention. He had often seen it urged of late, that by the occupation of Quettah, without saying anything about the expediency of that, England had given just offence to the late Ameer Shere Ali, because we were occupying a position claimed as part of the ancient Afghan dominion. Now the antiquity of this Afghan dominion did not extend beyond the middle of the last century, and it only lasted for one generation. It was a fragment of the last empire of Nadir Shah. One great prince of the Afghan line held it in succession from him, but in the time of his son it passed from him. It could scarcely be said that this was a serious offence to the Ameer, unless it was also considered that the English tenure of Lahore and Kashmir was an offence to him, because these places were equally parts of the dominion of Nadir Shah in the last century.

General Scott proposed a vote of thanks to the Chairman, which was carried unanimously, and a similar compliment to the author of the paper, brought the proceedings to a close.

AFRICAN SECTION.

Tuesday, January 21; Mr. Hyde Clarke in the chair.

The Chairman, in taking the chair, said he did so on account of the retirement from that position of Admiral Sir Erasmus Ommanney, who had now left town. The section originated at the meeting of the British Association at Brighton, when Admiral Ommanney presided over the Geographical Section, and when some very valuable papers were brought forward on East Africa. At that time East Africa was a matter more of speculation than of reality, but Admiral Ommanney was far-seeing enough to know the importance of the operations then going on there, and he then remarked how much it was to be regretted that such papers as had been brought forward should not be followed up, and produce some practical result. He (the Chairman) suggested to him that if the subject was brought before their Society, authority would be given for the formation of an African Section, by which means not only the development of East Africa, but also the interests of the other regions of the great continent, could be brought more directly before the public. This was done, and Admiral Ommanney undertook the chairmanship of the section, and admirably carried out his duties. The primary object he had in view, the development of East Africa, had been well kept before the members and the public, and it had now become, not a mere matter of speculation, but was looked upon as a practical resource for the development of English commerce. With equal satisfaction they might look upon what had been done with regard to West Africa, about which little was known, although year after year a vast development of commerce was taking place there, so that now, to the most barbarous regions, where it was even difficult to prevent human sacrifices, mails were carried weekly or twice a week. It was not necessary to enlarge on the attention bestowed on South Africa, but he was quite satisfied that very much had been done there to advance South African interests. Fortunately there was another institute, the Royal Colonial, devoting much attention to the colonies, and with it that Section of the Society of Arts had worked in harmony, but not able to give so much attention to Africa as that section. One of the practical results of the interest which the President of the Society of Arts, the Prince of Wales, took in the Exhibition of Paris was, that the fine colonial department which attracted the admiration of every visitor, might become the nucleus of a permanent colonial museum in London. It was unnecessary for him to say anything with regard to North Africa, because it was about to be treated by Mr. Cobb, who had already contributed one very valuable paper on Egypt, which he was now about to follow up and render more complete.

The paper read was—

EGYPT: RETROSPECT AND PROSPECT.

By B. Francis Cobb, F.S.S.

When I last had the honour of addressing you, about a year since, upon the subject of Egypt, and her then commercial aspects, I quoted suggestions of certain writers upon the desirability of an occupation of Egypt by this country, and, while deprecating any such movement myself, I stated, "I believe a joint protectorate by the two nations (France and England), of Egypt, as an independent country, would be better than any

occupation by England alone." Since that time things seem to have been progressing in that direction, and we have recently seen substantial aid procured for Egyptian finance under the auspices of the two Governments.

It may be also within your recollection, that I mentioned the vulnerability of the Canal, and did so rather in the view that the canal must be looked upon as the property of the civilised world, and not to be permitted to be made the victim of any wanton military aggression. I regret to find, however, that my innocent remarks produced an unexpected sensation on the spot, and the correspondent of the *Times*, writing of this at the time, says:—

"We are getting over our 'scare' about the safety of the Suez Canal. The Russians were not feared; they had not only undertaken to respect the open navigation, but nobody believed them able to come near. The alarm came from no ascertainable source, and was of an uncomfortably vague character. It was stated that certain persons, name and nationality unknown, contemplated the destruction of the banks with dynamite. No motive was ascertained; no one knew whence the destroyers would come or where they would make the attack. Sober-minded people who knew the country maintained the whole thing to be a hoax. But men in authority gave it credence; the British Government was informed and alarmed, and the Khedive was called upon, as usual, to pay the piper. An Egyptian canal police, by land and water, was organised, steam launches surveyed the waters by night and day, mounted Egyptians patrolled the banks, and an English official was appointed to take charge of the waters and banks of the canal. People are now only beginning to see that the danger was purely imaginary."

I had intended giving some description of this canal, but as I am informed that a copy of the beautiful model shown at the Paris Exhibition will be exhibited in this country, together with the statistics shown with it, I will not trouble you to-night with any minute description. Those who have had an opportunity of seeing that model will, I am sure, agree with me, that more can be learned from fifteen minutes' study of it than I could teach in the whole time allowed for a paper in this section. Briefly then, I may say, that this great engineering work is in itself of the most simple and unimposing appearance. A straight narrow water-way, traversing first the shallow waters of Lake Menzaleh, it passes on through the desert until it comes to the wide waters of Lake Timsah, where a fleet of moderate draft might congregate. Emerging thence through the desert, it reaches the Bitter Lakes, shallow salt waters, with a deep channel carefully marked out by beacons, and from whence it is easy navigation through desert until the Red Sea is reached. Every few miles there is a *gare* or station where the canal widens and ships may pass, and from *gare* to *gare* the block system is strictly maintained as regards vessels coming in opposite directions. The Canal Company is casing the sides with stones, in order to prevent the accumulation of silt from the wash of the ships. Here and there trees have been planted to hold the banks together. But the anticipated dangers of sand storms that would block the channel with their deposit from the desert have proved imaginary. The only real danger is the accumulation of silt at the Port Said mouth. A strong current sets along the coast from west to east, and bears all the Nile mud that runs into the sea to Port Said, where a constant fight goes on between the deep water channel and the perpetual deposit. Every year the breakwater is lengthened, but the danger will not be averted until powerful groins or breakwaters are erected along the coast, so as to divert the current to the northward, a most difficult task to successfully accomplish, for there is no doubt, as is shown from Commander Millard's survey, that a gradual shoaling of the whole sea basin in front of Port Said is slowly taking place, as is probably the case along the whole coast of the south-east corner of the Mediterranean; but although this may cause anxiety for the future, it is not as yet of a sufficiently serious nature to endanger the channel at the entrance to the harbour. The considerable deposit of sand, which regularly takes place along the inner side of the west breakwater, seems to be slightly on the increase since the advance of the western shore to the point where the breakwater is of a more open construction. It, however, causes no uneasiness to the chief engineer, who is confident of being able to more than keep pace with any such formation. That he has been able to do so up to the present time is proved by the excellent channel maintained.

Speaking of the financial position of Egypt last year, I mentioned the bad Nile, and I regret to say that the Nile has behaved equally badly this year, although in the opposite direction. It is difficult to understand, without having been in the country, the vital importance of a good Nile to the Egyptians. Ministers may legislate, and foreign Commissions suggest, but without a good Nile the finances of Egypt are temporarily crippled. There are thousands of acres within the banks of the Nile, what we might call foreshore, which are cultivated and pay taxes: they are seldom irrigated, because the Sheiks know that they are covered by the Nile every three years at least, and then they get one rich crop at a very small outlay, and, perhaps, a fair crop the next year, if the water has remained at a high level long enough to give time for the mud to settle. Sandy, dry, apparently worthless places become fruitful, especially if they fill gradually, and give the Nile mud time to precipitate.

Another serious matter hangs on a good or bad Nile. After a bad Nile it becomes low Nile in February instead of June the next year. It was so in 1869, when the heat and the desiccation of the country in the early part of the summer were terrible, and there being no head of fresh water inland to filter through and balance or keep out the salt water of the sea, it, by its greater specific gravity, percolated inland, and supplied the wells of Alexandria, tainted the waterworks, and salted the Nile for seven miles inland. At Rosetta the water was unfit for man or beast, the cattle died from it, vegetation languished, and people gave famine prices for a goat's skin of muddy, stinking water from such ditches in the country as the sun had not evaporated. There were just the elements for a plague or epidemic. The dock gates of the Mahmoudieh Canal were accused of letting in the salt water from the sea to the canal. M'Killop Pasha was accused of dredging the canal too deeply; the wildest notions went abroad; a Special Commission sat and deliberated upon the

subject, However, perhaps the real cause of this salting of the fresh water supply of Alexandria is better understood by this time, and, if we may judge by the remains of the extensive reservoirs of Roman construction in Alexandria, the Romans had no doubt found this out, and made these reservoirs to lay in a stock of fresh water to serve them during the low Nile periods. At every low Nile period the fresh water in Alexandria is bad, more or less; it was so last year; but after a very low Nile it is very bad, and may be the cause of an epidemic. Whether the waters of the Nile will ever be conserved to prevent such a thing would be very difficult to say, but the disasters to the country of the last two years have been of so serious a nature that the Government will be forced to give the matter their attention.

Such an inundation as took place last year becomes a national calamity, and its effects upon the finances of the country for the year are extremely serious. Probably, with proper care and watchfulness, it might have been avoided. Unfortunately, the Nile had risen to a full good Nile and was falling. The watchers, no doubt thinking all danger past, were congratulating themselves, and paying but little heed to the suddenly unexpected rising flood. Other circumstances occurred to make the situation worse. These sudden floods could be foreseen and provided against by a proper look-out at Khartoum, in the Soudan, and speedy intelligence from there to Cairo. But a breakdown had occurred in the telegraphic communication; the railway administrators, whose duty it is to see that such accidents are speedily remedied, were away, and, consequently, Nubar Pasha was not informed in time of the great second rise of the river. The stream not only rose higher after the fall had commenced, but it rose higher than it did in the celebrated rising of 1874.

Of course the present Government came in for its share of the blame, and the successful struggle with the great Nile of 1874 is cast in the teeth of the new Administration. The story is once more told how the Khedive spent night and day in personal surveillance of every dangerous point; how boats laden with stone were stationed at brief intervals the whole length of the river in the Delta, and watchmen with runners placed all along the banks; and how for a long week the country was in suspense, until the flood fell at last without effecting a breach. A large school building in Alexandria, erected by the foreign merchants, is the result of the gratitude which the community felt at the time to the Khedive. The comparison is against the new men. But they are not, after all, very much to blame. The country, politically, is in a transition state. There was never a strong Ministry of Public Works in the old days of personal rule, because the Khedive was his own Minister. Under the new *régime* of a constitutional government his autocratic influence for both good and evil is naturally withdrawn, and one of the first consequences of the change is a total collapse of the Department of Public Works.

This sudden devastating deluge may, however, prove an eventual benefit to the country, if the new Minister of Public Works, M. de Blignières, will only profit by the lesson. There is no doubt that the Nile might be brought under complete control, and distributed according to need. It might be so held in restraint that Egypt would be no longer subject to its caprices, and there would be water enough and never too much, whether the Nile were high or low. Irrigation schemes on a still vaster scale have succeeded in India, and have not only been an infinite benefit to the country, but have also returned a large profit on the outlay. The irrigation works in the Punjab, those of the deltas of the Godavery and Kistnah, in the Madras Presidency, are all proof how Egypt might be saved from a repetition of the calamity I have just described.

The following is extracted from the letter of an eye witness, and may be of interest as showing the havoc created by the flood:—

"Continuing the journey by rail I reached Mehalleh-el-Kebir, a flourishing town in one of the richest parts of the Delta. The cotton grown in this district is held in high estimation on account of its superior quality. This year, however, Mehalleh has but little to boast of, for although the place itself, with its hundreds of mosques and minarets, has been spared, and may still glory in being one of the most picturesque of Arab towns, the great source of its wealth, its cotton, is, alas! nowhere, The huge break in the dyke at Mit-Bedr, some fourteen miles off, let loose such a torrent of water that in twelve hours the whole district round Mehalleh was flooded, and fields of the finest cotton, of which not even the first pick had been got, were totally destroyed. Not only the cotton, but the dhoora crop, upon which much of the prosperity of the place depends, has also suffered severely, and the poor fellaheen will for a long time feel the effects of the calamity which has befallen them. It is not, however, the natives only who are the losers by the disaster. With all the European cotton firms 'up country' business is simply at a standstill.

"An hour's ride brings us in sight of the town of Samanoud, and to the spot where the railway has been literally swept into nothingness. The sight here is of a most remarkable character. The embankment in three or four places is clean gone, and the water rushes in big waves through the intervening gaps, which are from one to two hundred yards in width, The rails in many places, still held together by their iron fastenings, are totally submerged, and boats pass and repass freely over the channels thus newly formed. For weeks past all the traffic with Samanoud has been stopped, and that between the important towns of Mansourah and Alexandria has to be carried on by the circuitous route *viâ* Zagazig. On the upper Egypt line the same thing exists, and the natives are shipping their produce by the river. This is the more to be regretted, inasmuch as the Egyptian railways have, apart from this untoward circumstance, profited less hitherto than any of the administrations from the new European management. The receipts for the first half of this year showed a falling off of thirty-nine thousand six hundred and eighty-two pounds as compared with 1877, and it is evident that, in the face of the present disasters, a still further diminution must be anticipated."

Another writer states, later on:—

"The great breach near Samanoud has been slowly filled. But there are over ten feet of water covered pretty nearly a whole province, and the loss of cotton alone is now put at over 200,000 cantars, or £500,000. It is, however, consoling to think that the rich deposit of virgin soil will remain as the waters drain off."

For some time past, my attention has been drawn to the connection between sun spots and full Niles, and as the Nile really is a gigantic rain gauge, if there be any truth in the connection between

cyclones, famines, and sun spots, according to the theories of Dr. Hunter and Messrs. Meldrum and Lockyer, or the shipwrecks, as shown statistically by Mr. Henry Jeula, then we ought to be able to foretell such a disaster as has just happened by the solar spots. I am bound to say that I have failed entirely to trace any connection with the cycle of eleven years. True, the cycle is not eleven years exactly, but Lockyer makes the cycle above and Proctor below that period.

Here are the figures:—

1866	..	$28\frac{1}{4}$ ft.	minimum spots.
1867	..	$24\frac{1}{2}$	minimum spots.
1868	..	19	
1869	..	$29\frac{1}{4}$	
1870	..	$25\frac{1}{2}$	
1871	..	$23\frac{3}{4}$	
1872	..	$25\frac{1}{2}$	maximum spots.
1873	..	20	
1874	..	29	
1875	..	24	
1876	..	25	
1877	..	18	minimum spots.
1878	..	30	

It is impossible to say that the rule, maximum spots, maximum rainfall, applies to Egypt. The cause of the irregularities of the Nile must clearly be looked for locally, the Blue Nile and Nyanza lakes having probably more to do with the matter than sun-spots. The telegraph, combined with a vigilant series of observations of the Upper Nile, especially at the confluence of the Blue Nile, will prove more reliable for the protection of Egypt another year than any calculations based upon solar physics.

A recent decree of the Khedive appoints a Minister of Public Works to act conjointly with the Minister of Finance.

This decree is probably one of the most remarkable published in Egypt since the time of the Pharaohs. It is open to criticism, as being ambiguous and illogical in the distribution of duties, but the stride is immense, and I believe that the Khedive means honestly to give the new system of ministerial power and responsibility a fair trial. It remains to be seen whether the people are ready for its application. Opposition they certainly will not offer. The Egyptians will always acquiesce in the ruling influence. But any active participation in the work of government cannot be expected, and a certain amount of restraint—of benevolent despotism—may still be necessary. Up to the recent foreign intervention there is no doubt that taxes were only obtained by compulsion. It is difficult to suppose that an uneducated people will lay aside their habits of retention and tacit opposition at once. Time only will teach them their error. We must not suppose, however, that everything will go quite smoothly. No insurmountable obstacle exists to the establishment of the new form of government; but a certain opposition may have to be encountered from those who have profited from previous systems, and complete success will only come with time.

The following is the decree:—

"We, Khedive of Egypt, on the proposal of our Council of Ministers, decree,—

"1. The administration of the railways is placed under the control of the Minister of Public Works.

"2. The administration of the port of Alexandria is placed under the Minister of Finance.

"3. The Ministries of Finance and Public Works shall have all the rights reserved to ourselves by the decree of the 18th November, 1876 [this refers to the right of nomination of the administration of the railway and port of Alexandria], always subject to the reservations made by our letter of the 28th August, 1878 [this refers to the right reserved by the Khedive to have every decision of the Ministers submitted to him, and to make all action on any decision depend on his sanction of it].

"Our Ministers of Finance and Public Works are entrusted, each in what it concerns him, with the execution of this decree. Made at Cairo, 10th December, 1878. (Signed) "ISMAIL, Khedive.

"NUBAR, President of the Council of Ministers."

Then follow the details, some of which are so remarkable that, but for the fact that they have been mostly published in the newspapers, I should have liked to have reproduced them. They provide, among other things, that the Home Minister shall control the officials appointed for the abolition of the slave trade, the sanitary service, the hospitals, &c. The Minister of Public Works shall control the maintenance of all property belonging to or hired by the State, have the management of all matters connected with water, viz., canals, barrages, sluices, bridges, dykes, roads, &c.

Reference is frequently made in the decree, and in the details to the letter of the 28th August, 1878; and as this letter has been to some extent the foundation of the present constitutional Government, I give a translation of that portion bearing upon the mere evidence of the desire of the Khedive to make the change complete and effectual.

"Giseh-palace, 28 August, 1878.

"My dear Minister,—I have carefully thought over the changes in our foreign and home affairs produced by recent events, and while you are busy in forming a new Ministry, I wish to assure you of my firm desire to place the rules of our new Administration in harmony with the principles which guide the Administrations of Europe. Instead of a personal power, the present guiding principle of the Government of Egypt, I want a power which, while it has its weight in the general direction of things, stills finds its counterbalance in the Council of Ministers. In a word, I want to govern with and by my Council of Ministers.

"Following out this line of thought, I hold that, in order to carry out my reforms, the members of the Council of Ministers ought to be each dependent on the other and, acting as a body, discussing every important question, the majority governing the minority, and, by my sanction, I will adopt the opinion which prevails. Every Minister must carry out the decisions of the Council which have been sanctioned by me, and which concern his administration."

The *bona-fide* intentions of the Khedive for the future crop out in various and unexpected ways; for instance, a correspondent of pretty good authority, writing from Alexandria only last month, states:—

"I have already referred to the economy to be effected by the partial suppression of the Poste Khedive Line of steamers. I now hear that retrenchment has begun in a quarter where it was least expected, viz., in the harem itself, some twenty or thirty discarded favourites from which have been sent away within the last few days. Any one who knows the expensive habits of 'Fatima' or 'Zahrah' will recognise that this reduction in the Viceregal household is of more importance than might be imagined, especially

as it may be only the beginning of further changes in the same direction. Every one of these beauties, on quitting the palace, is married according to the Mohammedan law to any one willing to take her, and as each, apart from other attractions, is provided with a dowry varying from one hundred pounds to one thousand pounds, husbands are readily forthcoming. I am told that these ladies are much sought after in the matrimonial market, the class of suitors deemed most eligible being the holders of small government appointments. Life in the harem has by no means subdued the spirit of these Oriental houris, who are far from being the 'soulless' slaves which poets have imagined. This was exemplified by one of them, who, having the other day united her lot to an official here, refused to live in the commercial atmosphere of Alexandria, which her husband had, therefore, perforce to abandon for the more aristocratic city of Cairo.

"One noteworthy feature in the arrangement is the complete exclusion from power of the various members of the Viceregal family. But a few months ago, one of the Khedive's sons figured as Minister of Finance, another as Minister of War, and a third as Minister of the Interior; now all are relegated to private life, a fate the more hard at the present moment, when, having just parted with their estates, an official salary might be particularly welcome."

In the responsible ministries appointed, Nubar Pasha is president. This gentleman is one of the very few Oriental statesmen who have really grasped the necessity and magnitude of the task imposed upon an Oriental Government in contact with Western civilisation. It is not a question of putting off complaints and appeasing local or foreign creditors; the choice is between a thorough reform in both method and details of administration, however disagreeable, or extinction at a time not very far distant. And this is what Nubar Pasha is said to have foreseen for years past, and his too plain speech and warnings offended both his master and the financial vultures who were preying upon him.

The facilities always given to the rulers of Egypt to pile up a floating debt is one of the greatest troubles the new administration has had to deal with, and the operation of the new courts of law do not ameliorate this trouble; on the contrary, where all the proofs of the debts and the accumulated interest are easily proved, it is difficult for the judges not to give judgments which, in unscrupulous hands, must increase the difficulties of the Finance Minister, already overburdened by the decreasing revenue resulting from the effects of two bad Niles, at a time of great commercial depression; for not only has Egypt to suffer from diminished production, but from the low prices of her produce which have been and are now ruling.

Many persons appear to have expected Mr. Rivers Wilson, and M. de Blignières, to wave a magician's rod over the banks of the Nile, and produce financial miracles as remarkable as the miracles produced by the magicians of olden time; but time and patience must necessarily be important elements in the regeneration of Egypt. The start has been fairly made, the path opened, and it remains to be seen whether the last two years of accidental disaster may not result, in the end, in a greater prudence and complete circumspection which rapid success would have made more difficult to arrive at. On the other hand, the country has been emancipated from Turkey; the endless calls from the Bosphorus for "backsheesh" have ceased; the palace intrigues of Constantinople no longer shake the Ministers at Cairo; the tribute is perhaps the sole link that remains. The power to reform, as well as the will, is in the hands of those who rule the State, who are not only backed by the public opinion of Europe, but also by the fact that the two great Western Powers have officially stated in the correspondence on the Anglo-Turkish Convention their intention to "urge with earnestness the prosecution of those reforms which alone can rescue the Khedive's people from misery, and his finance from its present condition of profound embarrassment." But we must not forget that the work has still to be done, and must be patient with those who have to do it. Many centuries went to the making of English freedom and prosperity. We must not grudge a few single years to the Egyptian regeneration. The country is small and compact, the people are eminently docile, diligent, and intelligent, and, fortunately, the party averse to change has lost its old power.

It has been stated that all the schemes to emancipate Egypt have ended in a fresh loan, and that the Goschen-Joubert scheme has been no exception, the recent Rothschild loan being the natural *finalé* of an attempt to rectify Egyptian finance.

Throughout the present Khedive's reign we have had debt heaped upon debt, until the credit of Egypt was exhausted, and its resources began to fail. Then came a temporary default, inquiry after inquiry, and a composition with creditors; when a solemn promise was recorded that no more borrowing should be resorted to. In spite of this contract we now find a fresh loan. It would be unjust, however, to confound the present transaction with the former loans to which we have been referring. The present loan is effected for the purpose of winding up the accounts of a *régime* which, it is hoped, has finally been brought to an end, of stopping effectively the bad old system of borrowing, and of starting independently the new Administration that has been established. It is not the caprice of an irresponsible despot, reckless of his subjects' welfare, but the deliberate act of European financiers, determined upon only after careful scrutiny and consideration.

The loan is to bear interest at five per cent., and the amount is not to exceed eight and a half millions sterling. The Daira lands and houses which have been ceded to the State are mortgaged as security for the loan, but as the Daira Sanieh was already pledged for Daira loans, it is added that any deficiency which may occur will be made good from the general revenue of the country. On the day before this decree appeared, the Princes and Princesses of the Viceregal family completed at Cairo, according to the formalities of the Mohammedan law, the cession of their lands and houses to the State, which, on the occasion, was represented by Nubar Pasha, President of the Council of Ministers. And at the same time as the decree authorising the loan there was issued another decree, countersigned by the President of the Council, confirming the cession of those lands and houses, and transferring them in perpetuity to the State. Thus was completed, with the formal sanction of law, the Khedive's surrender.

It remains to inquire whether this new loan will not overload a country already staggering under

an excess of debt. In answer, we have the fact that the loan is negotiated by an English official of high standing, and that he considers the moderate interest of five per cent. sufficient to cover the risk run by investors. We cannot suppose for a moment that he would increase a debt already too large. It was quite open to him to have made other arrangements, or, in view of the recent recurrent disasters of the Nile, to have reduced the interest on the unified debt to five per cent., which, in my humble opinion, would have been a wise act.

It is said, I know not how truly, that French influence was used to hinder a reduction in the charge of the whole debt. It would seem that an estimated deficit this year and next should be proof of the need of such reduction. At present Egypt is paying with one hand and borrowing with another. Even if the deficit be due to the Nile and the depression of trade, the argument is not affected. It would be better for the bond-holders to take only as much as Egypt is really able to pay, than to stand upon the letter of their bond, and so, perhaps, assist in the contraction of a new floating debt. As Mr. Rivers Wilson has not done so, and has consented, as Finance Minister, to add to the debt, he gives the strongest proof of his own confidence that the country is able to discharge its obligations. This confidence is really almost all that the general public have to guide them in forming a judgment in the case. The hypothecation of the Daira lands derives a value from the same circumstance that it is the act of Mr. Rivers Wilson, and from the further fact that the lands are to be managed by a European Commission. As long as the present Cabinet lasts, it will not permit the revenues so pledged to be diverted from the purposes they ought to be applied to. And it is reasonable to expect that European management will very considerably enhance their value. The income they are stated to have yielded in the past is surprisingly small—very much smaller than the same quantity of land usually returns. Whether there was waste, malversation, or suppression of the income is not ascertained, but there seems good ground for anticipating very augmented productiveness with better and more honest administration.

The administration of the railways is to be under the Minister of Public Works, M. de Blignières. Placing the railways under M. de Blignières is not unlikely to create, rather than remove difficulties, for General Marriott's position is already defined by the decree of November, 1876, by which Egyptian railways were transferred entirely to the management of himself and his French and Egyptian colleagues, as a security for the preference stock. It would, therefore, seem that the authority of the Minister of Public Works in regard to this class of State property must be very limited, at all events until the preference stock has been paid off, and the Egyptian railways have again become an ordinary State asset. The result of the railways under General Marriott has, up to the present, been disappointing, but it must be remembered that not only has the Nile, the commercial depression, and the first inevitable difficulties of transfer of administration been against them, but repairs to permanent way and rolling stock were a necessity before a European could take up the responsible management. All expenditure of that sort had been studiously avoided for years past. But once that is done, their maintenance is by no means diffiucult. The country is flat. There is no tunnel, no cutting, no embankment, and no curve of consequence on any line in Egypt. Bridges over rivers or canals are the sole expense, and they are infrequent. The exemptions and reductions said to be allowed in the carriage of Daira produce will be abandoned. European management will increase the receipts by various obvious economies and alterations.

In the important item of coals, an extraordinary reduction was made during the last years, 1877 and 1878. Notwithstanding that the failure of the grain crop was so great that its exportation was prohibited—and this was estimated to be a loss to the railway of over £120,000—the receipts for the year are now expected to come pretty close to those of the previous one. It takes time to supplant Oriental by European management, and the first years are almost certain to show a loss. It must also be remembered that the international direction is cumbrous, and gives the management an appearance of caprice. Merchants, in making their contracts for the coming season, ought to be able to calculate on a certain stability in freights. The increased use of the waterways is only a subject of congratulation as far as the country at large is concerned; but it requires careful thought on the part of the railway, as regards the amount of extra convenience they should offer to customers, especially as such customers are obliged to make contracts and complete arrangements far in advance.

In Mr. Cave's report, the following remark may be remembered:—

"The net revenues of the railways have increased from £750,000 a year in 1873, to £990,800 in 1875, but this rate of increase cannot be entirely relied upon, as more of the gross receipts will necessarily be required for maintenance and renewal as the permanent way becomes worn, and deficient crops would cause diminished traffic."

I have here a statement of the amounts paid by the Commissioners to the public creditors during the last two years, from the 18th Nov., 1876, to the 18th Nov., 1878. The total is positively startling when one remembers what a poor, exhausted country Egypt is so often said to be. The sum paid amounts to £12,320,901, and this does not include the payments made on account of the Daira debt. Thus over six millions a year have gone out of the country; for, unlike the National Debt of England, France or other European countries, the national stock of Egypt is almost wholly held in foreign hands. There has not been default made in the interest of any one of the loans; of the unified debt five coupons have been paid. Eight millions have gone to interest, and over a million to liquidation of principal. Four coupons of the preference stock have been met, and to a million and a quarter of interest must be added a deduction of £74,000 of principal. Half a million has gone in interest on the short loans, and a million and a half in reduction of principal. The totals are:—

	Interest.		Redemption by drawings and purchase.
Unified Debt	£7,910,816	..	£1,135,516
Preference Stock ...	1,297,275	..	74,000
Short Loans	488,270	..	1,415,024
	£9,696,361	..	£2,624,540

To complete the picture, it must be added that no loan, save a wholly unauthorised one of £160,000 from the Bank of Egypt, was contracted during the two years until the recent large loan, which is really the price of property ceded to his creditors by the Khedive. The contrast between this period, with its vast payments and no new borrowing, and the previous period of extravagant expenditure and ever-increasing indebtedness, speaks eloquently for the Goschen arrangement and the strength of its control. That arrangement was, in fact, a new departure, and its great importance must not be forgotten in contemplation of the recent arrangements.

It is clear that our future policy towards Egypt should be the very reverse of what it was years ago. We should foster Egyptian self-development and self-reliance, and should encourage Egypt to look, not towards Constantinople, but towards the West. So long as we believed in the Ottoman Empire, we could not afford to strengthen ourselves in Egypt at its expense. That state of things is now entirely changed. The old European guarantees are hopelessly broken up, and if ever we fight for the Bosphorus in the future it will be for ourselves only. It is, therefore, as much our interest to see the bonds between Egypt and the Porte relaxed as it formerly was to see them maintained. Short of acquiring in some way a more positive and direct control over Egypt or the Isthmus, one can hardly imagine a better safeguard to the interests of the Western maritime nations than a reformed and renovated Egypt, having no longer anything to hope or fear from the Porte, content to bide its time for complete independence, and carrying out maturely devised plans of financial and social improvement under English advice. Improved government of the country will be an excellent thing, not only for the inhabitants of Egypt, but for all commercial nations, and for England and France in the first place.

What enduring causes have conspired to keep Egypt alive when, century after century, she saw around her dynasties, political systems, and even whole peoples pass away under the sword of the conqueror, or the slower operation of time? Why has this one nation risen again, after successive waves of conquest, inhabiting the same territory, and pursuing for generation after generation almost the same occupations? It would seem at first sight as if their wise men of old had discovered something corresponding to the process of embalming. Yet this analogy does them scant justice, for the mummies wear merely the semblance of life; while the Fellahs live and transmit to their posterity lands, rights, and traditions of tillage. The answer is that the physical conditions of the country forced the people into unity and obedience, a long river facilitated communication. It was easier to cross to the opposite bank, even in a frail canoe, than to make tracks through the deserts which, as a rule, extended backwards from the banks. A great river, therefore, partly accounts for Egypt as it was. But the Nile had a special characteristic which forced on the Egyptians an early organisation. Its periodical rise and fall affected alike many square miles of territory; and thus a common interest and anxiety united the whole population on the banks. Moreover, it was soon seen that the tillers of the soil were dependent on each other; that steps necessary to secure irrigation or mitigate the flood were too colossal and too costly for any single occupier, and that all must unite in order that each should prosper. One directing mind was essential, and to this Egypt owes her early kings and her system of despotism, based on giving the peasant freedom and facility for toil, with such share of its fruits as would keep him content. For thousands of years the process went on; the Fellah tilled, while the ruler taxed. Sometimes the burden was light, because the sovereign was unambitious; sometimes the bastinado and the torture let the poor villagers know that their tyrant had entertained or executed great projects—a pyramid, a war, a score of palaces, or a great canal.

Why has a system so miserable, so destitute of all the elements of progress, not ended, as elsewhere, in national catastrophe or decay? Simply because Nature has redressed the balance; for the Nile has compensated for the cruelty or folly of man. The beneficent river washing down soil from the interior has practically made a new Egypt every year, and the Fellah finds his farm prepared for his crops without lifting a hand. Exhaustion—the natural result of tillage without capital—is impossible in a land where the Nile is partner with every peasant, and does a lion's share of the farm work.

Thus we see, from age to age, people patient, industrious, and individually poor, producing a national wealth that nothing can quite destroy.

Rome has been called the "Eternal City," but Egypt was old when Rome was not in being, and she still stands an eternal nation, the brightest spot in one great Continent, an object of incessant interest to the other two, while the greatest highway in the world runs through her soil.

DISCUSSION.

Mr. Ankitell thought Mr. Cobb had made it clear what were the evils which had affected Egypt in the past, and what were her hopes for the future. As a long resident in Egypt, he could confirm what he had said, and might give many illustrations of his statements. He was in Egypt in the time of Abbas Pasha, of Seyd Pasha, and during the time of the present Khedive, whom he had had the honour of serving under, but the system of administration had always been the same, one of corruption, originating with the highest and going down to the lowest. No industry could ever prosper, because there was nobody who wished it to prosper unless he could benefit himself by it. The great mistake of the Khedive had been in supposing that the possession of property should be his great aim; on the other hand, he ought to congratulate himself that he was no longer the largest proprietor in Egypt. At one time he (the speaker) had under his charge the introduction of the cultivation of silk, which was perfectly successful as far as it was carried; and he would mention one fact to show how things were managed. When he was ordered to make a plantation of mulberry trees, he told the Khedive he should require about 300 men; but, to his astonishment, he found, when he got to the ground, that 1,000 men were there, who were each to have 4 piastres a day. After a few days, 300 of them left, and in a few more days another 200, and in 10 or 15 days he had 60 men remaining out

of the thousand; yet he found, some time afterwards, that, in the accounts rendered, 4 piastres a day for 1,000 men were charged for a month, and that was passed to the debit of the silk cultivation. For some reason he could not understand, his position seemed to create some jealousy, and one night his whole magnanerie was destroyed; then it was said that the silk cultivation was not a success. This showed how impossible it was for any industry to succeed, or for the Khedive to make anything out of estates. He had known a case on a sugar estate of the Khedive, where 500 men were marched from one corner of the ground to another, and charged for four times over. His Highness could not control these things; but no man had shown more disposition to develop the resources of the country by making canals and other improvements. Mr. Cobb had made some allusion to Constantinople, and on that subject very little need be said; they all knew that a great deal of Egyptian money had gone to Constantinople, and that a sort of fear had been kept up in the Khedive's mind of consequences which had never been very clearly defined, but which always made him open his purse strings when called upon, to the great prejudice of Egypt, and certainly not to the benefit of her creditors. The financial divorce which had now taken place between Egypt and the Porte was, therefore, a matter for congratulation. Some things had happened of the greatest importance, although, at the time, they did not appear so, such, for instance, as the disappearance of the late Minister of Finance, for no great improvement could have taken place so long as he remained there. Now, the administration had got into the hands of intelligent and honest men. The position of Mr. Rivers Wilson and his associates reminded him very much of the effect which the electric light had on the gas companies; they felt a sort of fear of the consequences, but they had not yet quite persuaded themselves that the greater light must eventually destroy or overcome the lesser.

Dr Mann fully endorsed Mr. Cobb's opinion that the spots on the sun would not be found to have any direct relation to the high and low Niles, but it would be perhaps as well to state exactly how this matter stood. The last development of the rage for sun spot influence took the form of the discovery that the constantly recurring financial crises in this country were due to the sun spots; and he should like to point what really was the influence of the sun upon the great physical changes going on in the world. There was no doubt that the presence of sun spots had relation to the amount of force and energy issuing from the sun, and that when spots were abundant more solar energy was thrown out into space. When that was the case, the earth shared with all the other orbs in getting some increased force from the sun. There was no doubt either that movement of every kind on the earth was dependent on solar action; and when increased energy was thrown out from the sun it told immediately on the water of the earth, and raised more of it into the sky in the form of vapour. But this did not mean that there would be an increased rainfall in one particular spot, but only that, being more vapour, there would be a greater rainfall over the whole earth. In a case like Egypt, the amount of rainfall was due to the presence or absence of an ocean wind blowing over the high grounds of Abyssinia. Therefore though no doubt the sun spots had to do with the total rainfall, they had not necessarily anything to do with the local rainfall in one particular country like Egypt. This did not touch the interesting fact mentioned by Mr. Cobb, that the fertility of Egypt was due to the fall of rain at the sources of the Nile, which came down in the river, scattered its fertility over the whole valley, and prevented the exhaustion of the ground, because new soil was constantly brought down.

The Chairman said he must congratulate himself on the almost miraculous escape he had from both Mr. Cobb and Dr. Mann with regard to this question of the periodicity of crises. They had been kind enough not to state that it was by a paper of his thirty years ago that public attention was first directed in what he might term a scientific form to this periodicity. As many present might be aware, Professor Stanley Jevons, who was the great advocate for the application of the sun spot theory to commercial crises, had reproduced the statements he made 30 years ago, and thus fresh attention had been called to them. For his part, he was no advocate for what was called the sun spot theory, for he believed the sun spots had no direct bearing on the periodicity of commercial crises, or upon the height of the Nile; but as what Dr. Mann had said might appear to throw discredit on the periodicity of crises, he would briefly revert to the facts to which he had formerly called attention. He had then gone through the corn harvests, as shown by the prices in England for the last 400 years, for which data could be obtained, and his observations, which had since been repeated by Professor Jevons, gave a series of facts over six centuries, showing that there was a periodicity in the crops, and consequently in the commercial phenomena dependent on them, of somewhere about ten years. Professor Jevons had fastened on to that one fact, but had not referred to other observations he had made, which gave the clue to the question Mr. Cobb had raised, whether it was possible to predict these periods. There was certainly, in a long period, a periodicity of about 10 years, and if you laid out a diagram you would find this plainly shown, but yet in some places the lines of dearth or plenty would seem to come in the wrong place, and no one has yet been able to hit on the true law. He had stated that, as far as he could discover from the facts before him, there were besides the periods of 10 years, other periods of about 26 years, and likewise a period of about 104 years, and the opinion he formed was that these longer periods interfered with the shorter ones, and prevented any absolute calculation as to the future. At the same time the observation of these phenomena was not by any means an idle matter; there was this practical lesson to be drawn from it, that in periods of prosperity we must look forward to a period of adversity and prepare for it. Therefore the observation of Governments, and of the commercial community and financial institutions should be directed to these great phenomena of nature, which, after all, did govern the individual operations of man. With regard to the paper, the greatest credit was due to Mr. Cobb for the attention he had paid to the subject, as he did to every matter which he brought before the Society. From various circumstances, he could not speak freely on some parts of it, but he did not partake of the enthusiasm of the author, and he could hardly avoid uttering a few words of caution to the public with regard to Egypt. A great part of the paper had reference to the financial administration and the loans, and Mr. Cobb congratulated himself on the joint action of the English and French Governments, and the safeguard afforded by European management. He wished he could feel the same unalloyed confidence; but he could not. He agreed with the statement given of the past, and could give as many illustrations as Mr. Ankitell had in confirmation of it; in fact, even those who had never been in Egypt could match those statements from writers, even classical writers, and he would rather deal with the hopes which had been raised. He did not agree with the statement that the corruption of Egypt arose solely from high places, but rather gathered that part of the fault lay with the people themselves. If he rightly understood Mr. Cobb, he really told them, as all history did, that the people of Egypt were, in reality, a slavish population, and the people had a greater influence in most countries on the Government

than the Government could have on the people. If the people of Egypt were not what they were, it would be impossible for that abominable system of Government, which had in no way been exaggerated, ever to have existed, whether under Egyptians, or Turks, or their predecessors, the Greek or Roman Emperors, or the Pharaohs. It had always been the same, and that diminished his confidence as to the prospects in future for what was called a thorough reform. This confidence was not strengthened by the approved modes put forward for correcting evils. They were told to rely on the joint action of England and France. Under certain circumstances they might do so, but even during the last few months there had been evidence that feelings of jealousy might prevail between the two powers, and they must look forward to a time when they must be in antagonism with respect to this very country. When they were told, too, about European supervision they should ask what it meant. It meant in this case the intervention of three peoples of different views and different habits, and modes of administrations, Englishmen, Frenchmen, and Italians, and under such circumstances collisions must take place. He said this the more particularly because he had been one of the advocates for the employment of Europeans in Egypt and Turkey. What he had proposed, however, was something of a very different nature from what had been done. He never contemplated that they were to transplant to Egypt a set of clever officials who had no previous knowledge of such a state of things as they would find there, and no means really of applying the knowledge they possessed. What he advocated, and what had been supported by many others, was that the Europeans sent there should be persons who, from their previous experience, would be able to apply their knowledge to the circumstances of the country; those who had been in the Indian Civil Service, but carefully selected, not men from the settled provinces, like Bengal, but from presidencies and districts where the same system of finance as prevailed in Egypt had been in existence, and had been modified by the influence of English government. Although few of these men spoke Arabic, yet they would readily acquire it, and, the technical terms of finance being the same in Egypt, India, and Turkey, they would know what they were about, and be prepared to acquire the additional information necessary for the application of their knowledge. Entertaining the same views as Mr. Cobb did, that it was necessary to give the French a participation, he proposed that the Frenchmen employed should be of the same class, and they could have rendered valuable assistance, because they had a class of officers trained in the same way, and even better educated for the work, namely, those in the Bureau d'Algérie. Those men had a knowledge of Arabic, and were accustomed to the same kind of financial administration as was carried on in Egypt. He said this partly in vindication of himself, because he had been charged with having advocated what was called the employment of Europeans, whereas he never advocated it in the shape in which it had been applied; what he advocated he believed was practicable, but what was now adopted, would, he feared, give rise to greater evils than those which had occurred. Even Mr. Cobb had found it necessary to apologise for events which were familiar to all. Not one of those epochs of reform but had been accompanied by a loan, and he wished that were all. He looked upon it as a very unfavourable indication of the new administration, that the exceptional privileges of exemption from tithe enjoyed by some lands should be abolished, for that could scarcely be considered as anything but one form of repudiation. It gave the new administration larger revenues, but accompanied by a danger to the rights of property. Even men, influenced by highly benevolent motives, like Mr. Cobb, advocated repudiation, for he had suggested whether it would not be better for Egypt that Mr. Rivers Wilson should have adopted the measure of reducing the interest on the unified debt for the benefit of the population, a population that at no period had been able to do justice to itself and never would. These loan operations gave large commissions to the financiers and bankers who carried them out; they paid the exorbitant claims of the persons who had speculated at the expense of the Egyptian Government, but the ultimate result was that these loans were placed amongst the saving people of all classes in England and France, and the result of the operation was that they became participators in what was called the welfare of Egypt. Already there were grounds for fearing that the new administration would not do all that had been expected of it, and it was a question even whether it had not already slackened the bonds of Government. The late excessive inundation was probably due not only to the Director-General of Railways, but to the circumstances that the same stern laws of labour were no longer applied. To the theorist it appeared very hard that the population should be compelled to give forced labour, and in this country happily every man had a right to his own labour, and to make his own price of it; but under the climatic circumstances described by Mr. Cobb, it might be necessary to apply a totally different meaning. What was the state of things in Holland? If the storm bell rang to notify that the dykes were in danger, the whole population must turn out and work for the safety of the general community. Laws must be applied according to the practical circumstances; and it was positively necessary in Egypt that there should be a strong Government for the purpose of applying the labour of the community for the general benefit. It was very difficult to see how, with such a population, increased schoolmastership could really be for its advantage. The problem to be solved was, whether it was possible to give to the Fellaheen a greater proportion of the produce which they raised; but it really might be for their benefit to have a smaller portion. You wanted time for all these operations, and you might make these people lazier by relaxing those bonds of discipline which had always been maintained over them, than by assigning them less than they had hitherto enjoyed. If any other population in the East with which he was acquainted had been treated in the same way as the population in Egypt they would certainly have revolted. It was scarcely possible to conceive what the population laboured for with so much assiduity, so small was the share they got of the proceeds of their labour, and so small were the enjoyments of their lives; still they must take care not to make the condition of the country worse instead of better. He concluded by moving a vote of thanks to Mr. Cobb for his paper.

The motion having been carried unanimously,

Dr. Mann said he wished to explain that in the remarks he made he did not intend to imply that there was not a periodicity and regular order of some kind in social conditions and events which were connected with the requirements of finance, crisis, and things of that kind. He was quite satisfied that there was. But he thought there was too great an inclination to refer locally restricted events to large general causes. He did not, however, think that such had been the Chairman's method of procedure. He believed that in his investigations his plan had been simply to trace periodicity of recurrence in events known to have occurred, and to infer that regularity in periodicity implied fixed causation of some kind.

Mr. Cobb said the remarks of the Chairman went over so much ground that it would be impossible for him to reply to them all in the limited time at his disposal. There was no doubt that, to a great extent, the tenor of his paper was to ameliorate the condition of the fellahs, but he had also in his mind the foreign bondholder, and he could

not see that, if as was shown by the committee of inquiry, the fellahs of the present day were paying the utmost which could be squeezed out of their miserable lives, how you could, by insisting upon full payment of the coupons, get more, and he asked whether it would not be better to accept the interest which Egypt could pay than to grasp at the whole which the creditors were entitled to, and let that result in the state of bankruptcy which must follow. He thought, too, the Chairman had slightly misunderstood the view he took of the future. Speaking from a financial point of view, he did not quite see how the next coupons of the unified debt were to be paid in full, especially with the attachment of the Dairah property which had just taken place, and the fact that, until this attachment were removed, Messrs. Rothschild would not advance any more money. He had all that in his mind, but, being so much a matter of politics, he had not thought it right to bring it forward. The argument that education and a better condition of the people would hardly improve them, and perhaps make the position of the Government worse, reminded him of some of the arguments of the Southern slaveholders. It had not been borne out by facts when the slaves were emancipated. He had himself seen the lower class of population in India and China improved by the education which had been spread amongst them; and, though it was quite true that with that education a certain resistance to an unbearable amount of taxation had been manifested, he thought for the sake of humanity they should rather contemplate a benefit to our fellow creatures than the payment in full of coupons held by foreign bondholders. By way of conclusion he should like to mention a few facts with regard to this sun spot theory, which formed a nut for Dr. Mann to take home and crack at his leisure. Starting with the year 1839 and ending with 1878, he found that during that time there had been 35 University boat races between Oxford and Cambridge. Now, if the results of these races were compared with the maximum and minimum periods of sun spots, it would be found that Oxford beat Cambridge five times in the minimum years; that Cambridge beat Oxford five times in the maximum years; and that both were exactly equal in the intermediate years.

On the motion of **Dr. Mann**, a vote of thanks was passed to the Chairman, and the meeting adjourned.

SEVENTH ORDINARY MEETING.

Wednesday, January 22nd, 1879; B. Francis Cobb, Treasurer of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Bloor, John Uzielli, 20, Highbury-place, N.
Burt, George, 19, Grosvenor-road, S.W.

The following candidates were balloted for and duly elected members of the Society:—

Baynes, Donald, Forest-lodge, West-hill, Wandsworth, S.W.
Day, Lewis F., 13, Mecklenburgh-square, W.C.
Powell, William, Springfield-villa, Leeds.
Roberts, Abraham Francis, 96, Ladbroke-grove-road, Notting-hill, W.
Spencer, Earl, K.G., Spencer-house, St. James's-place, S.W., and Althorp-park, Northampton.

The paper read was—

THE MODERN SCIENCE OF ECONOMICS.

By Henry Dunning Macleod,
Barrister-at-Law.

It has happened in the history of nearly every one of the great sciences that it has undergone a complete transformation from the mode in which it was conceived by its founders, and there is also a stage in which it becomes necessary to introduce more powerful and refined methods of investigation, more comprehensive forms of expression, and more minute and exact observation.

A crisis of this nature has now arrived in the science of political economy, or economics, as I shall show you it may more aptly be called. Up to the present time there have been two great schools of economists, each of whom has done great, glorious, and immortal services to mankind, and if I had time I should have pleasure in doing justice to their merits; but on the present occasion the very necessity of the case obliges me to point out their defects and shortcomings, which have rendered it indispensable to effect a complete transformation of the science.

Sydney Smith has expressed the case in his usual lively way:—"Nothing will do in the pursuit of knowledge but the blackest ingratitude--the moment we have got up the ladder we must kick it down—as soon as we have passed over the bridge we must let it rot—when we have got upon the shoulders of the ancients we must look over their heads. The man who forgets the friends of his childhood is base: but he who clings to the props of his childhood in literature (and science) must be content to remain as ignorant as he was when a child. His business is to forget, to disown, to deny, and to think himself above everything which has been of use to him in time past; and to cultivate that exclusively from which he expects future advantage."

This exactly expresses the case with economics at the present day. Making ample acknowledgement of the priceless services done by the two preceding schools of economists, the fact is that political economy of Adam Smith, Ricardo, and Mill, is now exhausted—it is a *caput mortuum* from which no further good can be extracted; it is wholly incapable of grasping the great economic problems which demand solution at the present day, namely, those of credit, currency, and banking. In fact this school of economists have abandoned all these questions in hopeless despair. It is said that one of the most distinguished of living orators and statesmen has declared that the currency question has driven more people mad than anything, except love.

Highly as we may esteem the great economists of this and other countries, it is essential to remember the character of economic contests up to the present time. They have been almost entirely destructive. The first economists found the public mind and the administration infected with an immense mass of rooted prejudices, errors, and abuses. Their first efforts were, therefore, directed to sweep these away—to beat down and abolish false doctrines of various kinds, to extirpate bad and mischievous laws interfering with the natural order of things; to abolish legislative interferences with wages, with prices, and with the commercial intercourse

of nations; to establish, in fact, freedom of contract; and in this all schools of economists are agreed.

But while economists of all schools are agreed on what was the destructive portion of their science, when we come to the constructive or positive science, this agreement is at an end. Nothing can be more astonishing and lamentable than the differences of doctrine, and the antagonism of economists, on almost every point in the science, so as to create a widely spread impression that there is no such intelligible science at all as economics; an impression which I hope I shall remove from your minds by the considerations I shall lay before you.

Many, indeed, suppose that the establishment of free trade is the whole aim and end of political economy, but nothing can be more erroneous. The destruction of protection was only the first fruit of the struggle of the infant science, like Hercules strangling the snakes in his cradle, and not its consummation. In fact, it only clears the ground and removes obstructions from the erection of the positive science. During the heat, the turmoil, and the dust of the battle to establish a great practical principle, there is little time to attend to the niceties of language, and the exact expressions of science. But now that the great victory is won, and men are enabled to sit down in a quiet inquiring spirit, the time has come for a complete calm and deliberate resurvey of the whole science. And, as a matter of fact, there is at the present moment, throughout Europe and America, a general reaction and uprising against the school of political economy which commenced with Adam Smith, and has closed with John Stuart Mill.

Fully admitting all the admirable services they have done in time past, their total want of scientific arrangement, their complete ignorance of practical business, their glaring inconsistencies and self-contradictions, and, as I observed before, their total incapacity to deal with the practical problems which are of the deepest importance at the present day—and which I am well aware chiefly concern many of the gentlemen whom I have now the pleasure of addressing—have produced a general revolt against them. And the most advanced economists throughout Europe and America are rapidly declaring their adhesion to a far wider and more comprehensive system of economics, which I have been advocating for more than 20 years; which has given the solution of those questions of credit and banking which were abandoned as hopeless by the second school, and, by the acknowledgment of all men of business, has finally set at rest that terrible currency question which has agitated and convulsed this country for three-quarters of a century.

And now that I am going to bring to your notice one of those revolutions which have taken place in all sciences, I trust that you will bear with me whilst I make a few preliminary remarks which will greatly conduce to explain to you the nature of the case.

It is sometimes said that Bacon was the father of all modern physical philosophy; that he first showed the way by which all modern sciences are created. This is to a certain extent true, but it is very far indeed from expressing the distinctive merits of the Baconian philosophy. The inductive spirit was not the creation of Bacon, but it was the product of the European mind in the 17th century, and Galileo and other physical philosophers created other physical sciences wholly independent of Bacon. But the distinctive merit of Bacon has never yet been sufficiently appreciated. He did not create any special physical science, and it is just possible that the physical sciences might have been just as far advanced if he had never written a line. But Bacon did something much higher than creating any single science; he created the science of creating sciences. He formed in his stupendous mind the everlasting canons of inductive logic, by which all alleged sciences must be tested. He pointed out the methods by which the physical sciences must first be created, and then he had the marvellous prescience to perceive that the same principles of reasoning by which the physical sciences were created must be applied to the creation of the moral and political sciences. That is the matchless and undivided glory of Bacon. Before there was a single physical science in existence, he laid down the everlasting canons by which all physical sciences must be created, and then he had the miraculous sagacity to perceive that in natural sciences are to be found the types and standards of reasoning which are to guide us in the creation of moral and political sciences. He inculcated the study of physical science, it is true, for its own sake, but not for its own sake only, but as the foundation of moral science. It is his transcendent merit to have been the first to perceive and proclaim with the voice of a trumpet the great doctrine of the continuity of the sciences. He calls natural philosophy the great nursing mother of all the sciences, and complains bitterly of the damage they all sustained by being separated from her. And the progress of science has exactly verified the prescience of Bacon. The inductive spirit was the product of the European mind in the 17th century, and it was first applied to the creation of the physical sciences, and political economy was the product of the European mind in the 18th century. For political economy is nothing but the attempt to apply to the phenomena of society the same spirit of exact reasoning as had been applied to the phenomena of the material world. In the very short time at my disposal I can but touch very briefly on this point, and I can only say that since his time many writers have maintained the same doctrine; but I can only cite a few sentences from Mill.

He says, "The backward state of the moral sciences can only be remedied by applying to them the methods of physical science duly extended and generalised;" and, again, he says, "This truth is exemplified by the history of the various branches of knowledge which have successively, in the ascending order of their complication, assumed the character of sciences, and will doubtless receive fresh confirmation from those of which the scientific constitution is yet to come, and which are still abandoned to the uncertainties of vague and popular discussion. Although several other sciences have emerged from this state at a comparatively recent date, none now remain in it except those which relate to man himself, the most complex and most difficult subject of study on which the human mind can be engaged. If on matters so much the most important with

which the human intellect can occupy itself a more general agreement is ever to exist among thinkers —if what has been pronounced the proper study of mankind is not destined to remain the only subject which philosophy cannot succeed in rescuing from empiricism—the same processes through which the laws of many simple phenomena have by general acknowledgement been placed beyond dispute, must be consciously and deliberately applied to these more difficult inquiries. If there be some subjects on which the results obtained have finally received the unanimous assent of all who have attended to the proofs, and others on which mankind have not yet been equally successful; on which the most sagacious minds have occupied themselves from the earliest date, and have never succeeded in establishing any considerable body of truths so as to be beyond denial or doubt; it is by generalising the methods successfully followed in the former inquiries (that is, in the various physical sciences) and adapting them to the latter, that we may hope to remove this blot on the face of science."

Thus you will see that in this passage Mill exactly agrees with Bacon, and asserts that political economy, or economics, which is a moral science, is to be constructed on exactly the same principles, and by the same course of reasoning that physical sciences are.

I propose now, then, to show you the application of these remarks, and explain to you what is meant by saying that economics is a physical science.

Now, a physical science is a body of phenomena, all relating to one central fundamental idea or quality; and the business of the science is to discover the laws which govern these phenomena; that is, to determine the causes which produce certain effects; but these effects must be capable of numerical measurement, and the business of the science is to discover and express in exact language the causes which produce changes in the numerical relations of the effects. Thus, for instance, mechanics, or as it is more usually termed now, dynamics, is the science of force; and the object of the science is to ascertain the numerical effects produced by force. So there are many other physical sciences, such as those of light, heat, electricity, and others, and each of these relates to the phenomena concerning some single central idea.

But there is one fundamental principle relating to all these sciences to which I must especially direct your attention, as it will be found to be of the deepest importance in the science with which we are concerned this evening. It is this—that special quality or idea which is the basis of the science may appear in substances of the most unlike natures, and which agree in no other respect than in the possession of that single quality. But all these substances or natures, however unlike or dissimilar they may be in other respects, so long as they agree in possessing that single quality on which the science is based, must be reckoned as elements or constituents in that science. As, for example, dynamics is the science of force, and the definition of force is this, "a force is anything which causes or tends to cause a change in a body's state of motion or rest."

Now, that word anything is of a very wide nature, and, as you know, there are many distinct kinds of things which exert force. Thus, some forces are material, such as men and animals. Other forces are incorporeal, and invisible, and intangible, like gravity, electricity, &c. Other forces are explosive, like gunpowder, dynamite, &c. There are also the force of the wind. steam, &c. But all these various things are mechanical forces, and enter into the science of dynamics because they all possess the common quality of producing changes in the rest or motion of bodies; and yet they have no other quality in common, but that single one of force. What can be more different than man and gravitation? What can be more different from these than gunpowder or dynamite? And yet all of these distinct kind of things are included under the common name of force.

If, then, political economy, or economics, or the science of wealth, as it is called, is a physical science, and is to be constructed after the manner of other physical sciences, we must first search for that quality of things which constitutes them wealth; and then the science of wealth is the science which treats of the laws of the phenomena relating to that single quality which constitutes them wealth. And when we have settled and determined what that single quality is which constitutes things wealth, we must search for and discover how many distinct kinds of things there are which possess that single quality, and they must all be classed and included under the term wealth, no matter how dissimilar they may be in other respects, and even though they may have no other quality in common but the single one which constitutes them wealth. Nay, more, arguing from the analogy of physical science, we should naturally expect there would be several distinct orders of quantities which possess the attribute which is the essence of wealth. We should naturally expect there would be diverse quantities possessing the quality which constitutes wealth, just as diverse in their natures as man and gravitation; and just as the principles of natural philosophy compel us to class man and gravitation equally as forces, so we shall naturally expect to find quantities as diverse in their natures which possess the quality of wealth, and therefore, by the laws of natural philosophy, must be classed as wealth.

We have now, then, to determine what that quality is which constitutes things wealth; in fact, the meaning of the word wealth, and I hope that, in inviting your attention to this word, you will not think that I am going to amuse you with ingenious speculation or vain logomachy. On the contrary, this word is the basis of a great science, and there is none probably which has so seriously influenced the history of the world and the welfare of nations according to the meaning given to it at various periods.

For many centuries the legislation of every country in Europe was moulded by the meaning given to the word wealth. The celebrated French economist, J. B. Say, says that during the 250 years preceding his time, 50 years were spent in European wars directly originating out of the meaning given to this word. Speaking of the mercantile system which prevailed so long, and which was expressly based on a particular meaning given to this word, another economist, Storch, says, "It is no exaggeration to affirm that there are very few political errors which have produced more mischief than the mercantile system. . . . . It has made

each nation regard the welfare of its neighbours as incompatible with its own; hence their reciprocal desire of injuring and impoverishing one another; and hence that spirit of commercial rivalry which has been the immediate or remote cause of the greater number of modern wars. . . In short, where it has been least injurious, it has retarded the progress of national prosperity; everywhere else it has deluged the earth with blood, and has depopulated and ruined some of those countries whose power and opulence it was supposed it would carry to the highest pitch."

So Whately says, "It were well if the ambiguities of this word had done no more than puzzle philosophers. . . . . It has for centuries done more, and perhaps for centuries to come will do more, to retard the progress of Europe than all other causes put together."

These extracts, which are nothing but the literal truth, show you the gravity and the importance of the inquiry into which we are about to enter, and I hope we may do something this evening to remove this reproach. So that I venture to hope that the words I am going to say may not vanish from your minds as if they were written in sand on the sea-shore, but be rather as if they were written with an iron pen, and graven on the rock for ever!

We have then, first, to search for that single general quality of things which constitutes them wealth: and secondly we have to search for and discover all the distinct kinds or orders of quantities which possess that quality, and which, therefore, satisfy the definition of wealth; and are, therefore, to be included under that title, however diverse they may be in form.

Now Aristotle, the great Greek philosopher, says this:—*χρήματά δε λέγομεν πάντα ὄσων ἡ ἀξία νομίσματὶ μετρεῖται.* "And we call wealth all things whose value is measured in money," that is, everything which can be bought and sold or exchanged. And all ancient writers, without exception, held that exchangeability, or the capability of being bought and sold, is the sole essence and principle of wealth. Thus the celebrated Roman jurist Ulpian says, *ea enim res est quæ emi et venire potest.* "For that is wealth which can be bought and sold."

Now you will observe that we have here a perfectly good general conception, which exactly satisfies the canon I have laid down; and therefore it is fitted to form the basis of a great science. It is a conception as wide and general as the dynamical definition of force. And that single sentence of Aristotle's is the germ out of which the whole science of economics is to be evolved, just as the huge oak tree is developed out of a tiny acorn.

Having, then, adopted exchangeability, or the capability of being bought and sold, as the sole essence and principle of wealth, we have next to discover how many distinct orders of quantities there are which satisfy Aristotle's definition of wealth, or which can be bought and sold.

Now, first, there are material things, such as lands, houses, cattle, corn, jewellery, money, and innumerable others, which can be bought and sold. Every one now-a-days admits these things to be wealth, and therefore I shall not give any more time to discussing them.

There are, however, other kinds of things, or orders of quantities, which can be bought and sold; and in modern times there has been a vast amount of controversy as to whether they are to be admitted as wealth or not; and, it is to those kinds of quantities that I shall now direct your attention.

There is a very remarkable work of antiquity which is the earliest regular treatise that I am aware of on an economical question. It is a dialogue called the Eryxias, or the meaning of wealth; and, strange to say, its author is unknown. This dialogue is to the following purport. The Syracusans had sent an embassy to Athens; and the Athenians had sent a return embassy to Syracuse. As the ambassadors returned from Syracuse they met Socrates and a party of his friends, with whom they entered into conversation. One of them said he had seen the richest man in all Sicily. Socrates immediately started a discussion on the nature of wealth. Eryxias said that he thought on the subject just as every one else did, and that to be wealthy meant to have much money. Socrates immediately asked what kind of money he meant, and he described the peculiar nature of different kinds of money. He said that at Carthage they used as money leather discs, in which something was sewn up, but no one knew what it was; and he who possessed the greatest quantity of this money was the richest person at Carthage; but at Athens he would be no richer than if he had so many pebbles from the hill. At Lacedæmon they used iron as money, and that useless iron, he who possessed a great quantity of this at Sparta would be wealthy, but anywhere else it would be worth nothing. In Æthiopia again, they used carved pebbles, which were of no use anywhere else. Among the nomad Scythians a house was not wealth because no one wanted a house, but greatly preferred a good sheep-skin cloak. After giving some other similar instances, he asked why were some things wealth and other things not wealth? Why were some things wealth at some places and not wealth at other places? Socrates showed that whether a thing is wealth or not depends entirely upon human wants and desires. That things are *χρήματα*, or wealth only where and when they are *χρήσιμα*, that is, when they are wanted or demanded.

Thus we see that though many persons might be puzzled at the meaning of the word wealth, there is no possibility of mistake when we refer to the Greek, because *χρήματα*, which is the usual word for wealth and also money, comes from *χράομοι*, to want or demand; *χρήματα*, means therefore, anything whatever which is wanted or demanded, no matter what its nature may be.

Thus you see that it is human wants and demands alone which constitute anything wealth. Anything whatever which people want and demand, and are willing to pay for, is wealth, whatever its nature may be; and anything which no one wants and demands is not wealth. Socrates showed that gold and silver are only wealth so far as they can obtain for us what we want and demand; and that if we can use anything else to obtain for us what we want as well as gold and silver, such things are wealth just for the same reason that gold and silver are.

Socrates then instanced professors and persons who gained their living by giving instruction in the various sciences. He said that persons got

what they wanted in exchange for this instruction, just as they did for gold and silver, and, consequently, that the sciences are wealth; for the very same reason that gold and silver are, and that those who are masters of such sciences are so much the richer.

Now, in instancing the sciences as wealth, that of course is a general term for labour, for labour in economics means any exertion of human abilities and energy which is paid for. Thus you see that the author of this dialogue expressly classes labour under the term χρήματα, or wealth, and this exactly agrees with Aristotle's definition that everything is wealth whose value can be measured in money, because if you want a person to do any labour or service for you, and you pay him for such service or labour in money, its values is measured by money exactly as if it were a material chattel. Suppose you give fifty guineas for a horse, and you also have to give fifty guineas to an advocate to plead your case in court, the value of your advocate's exertion is measured in money just as exactly as the value of the horse is measured in money. And in fact, all modern economists treat labour as a commodity which can be bought and sold, and is subject to exactly the same laws of value as any material chattel.

This dialogue clearly enforces a doctrine which is of the greatest importance in economics; it is this, that there is nothing which is in its own nature wealth; whether a thing is wealth or not depends solely upon human wants and desires; that is exchange. Ability is the sole essence and principle of wealth; things are wealth only in those places, and at those times, where and when they are exchangeable, that is, where and when they are wanted and demanded, and consequently that they cease to be wealth when they cease to be exchangeable, that is, when they cease to be wanted and demanded.

You thus perceive that we have now found two distinct kinds of things which can be bought and sold, or whose value can be measured in money—(1) Material things, which you can see and handle, such as cattle, money, &c., and (2) things which you can neither see nor handle, but which you can buy and sell; and, though these two kinds of things have nothing in common except the capability of being bought and sold, they are each comprehended under the term wealth. This latter class of things is called by the French economist, Say, immaterial wealth; because it is wealth, but not embodied in any matter.

But yet there is another class of things which can be bought and sold; of a nature quite distinct from the two kinds which we have just been considering.

Suppose that you have the right to be paid a sum of money by some one else at some fixed time. You can sell that right to any one else. And if the right be written down on paper, the person who buys it from you may sell it again to any one else, and so on; it may be sold any number of times until it is paid off.

And there is an immense variety of other rights which can be bought and sold; as, for instance, you can buy and sell the Funds. And what are the Funds? They are nothing but the abstract right to demand certain payments from the State at certain intervals for ever. So, if an author writes a successful work, he has the right, for a certain time, to the exclusive profits to be made by selling copies of that work; and that right is called a copyright, and he can sell that right to any one else. Suppose that he sells his copyright to a publisher for £100, the value of that right is measured in money as exactly as if it were a material chattel, and therefore it satisfies Aristotle's definition of wealth; and therefore it is wealth. You can neither see nor handle an abstract right, but yet you can buy and sell it. It therefore possesses the attribute which is the essence and principle of wealth, and therefore by the fundamental principle of natural philosophy, it is to be classed under the term wealth.

Now in the Pandects of Justinian, which you are no doubt aware is the great code or digest of Roman law, which is the basis of all the existing law of the Continent of Europe, and whose principles of the law of credit have been recently adopted by statute as the law of England, it is laid down as a fundamental definition—"Pecuniæ nomine non solum numerata pecunia sed omnes res tam soli quam mobiles et tam corpores quam *Jura* continentur."

"Under the term wealth *(pecunia)* not only ready money but all things both movable and immovable; both corporeal as well as rights are included."

So Ulpian, one of the most celebrated of the Roman jurists, says—

"Nomina eorum qui sub conditione vel in diem debent et emere et vendere solemus. Ea enim res est quæ emi et venire potest."

We are accustomed to buy and sell debts payable at a certain event and on a certain day, for that is wealth which can be bought and sold.

And there are several other passages that I need not read to you, in which it is expressly declared that mere abstract rights of all sorts are included under the titles, *bona*, goods and chattels, and *merx*, merchandise.

For almost five hundred years after Constantine removed the seat of government from Rome to Constantinople, the language of the Court was Latin, but the people were Greek; consequently, though Latin was the official language, it was unintelligible to the mass of the people. The code or digest, commonly called the Pandects, was published in the year, 530 A.D., in Latin, but all the pleadings in the Courts were in Greek. The Latin pandects very soon fell into disuse; they were superseded by Greek treatises, transactions, and compilations. At last, in the ninth and tenth centuries, all the Latin legislation of Justinian was entirely swept away as obsolete, and a new code or digest was published in Greek, which was called the *Basilica*, and this, henceforth, became the law of the Eastern Empire, and has remained to the present hour the common law of the whole Greek population in the East. And in the Basilica, the Roman definition of wealth is re-affirmed.

Under the term χρήματα rights are included.

Thus you see that ancient writers have shown that there are three distinct orders of quantities which can be bought and sold—(1) Material things, (2) labour or service, and (3) rights of various kinds; and there is no other kind of thing which can be bought and sold; there is nothing whatever which can be bought and sold which is

not of these three forms—either it is something material, or it is some kind of labour or service, or it is some kind of abstract right.

Thus we see that the ancients possessed the true scientific instinct; they fixed upon a single general quality as the sole essence and principle of wealth, namely, exchangeability, or the capability of being bought or sold. They then searched out and discovered all the distinct kind of things which can be bought and sold, and expressly classed them under the terms *pecunia*, *res*, *bona*, *merx*, and also as goods and chattels, and therefore in economics as wealth. Hence there are three, and only three, distinct orders of exchangeable quantities, and all commerce in its widest extent, and in all its forms and varieties, consists in the exchanges of these three orders of quantities. And anyone with the least mathematical feeling can perceive that we have here the materials of a great mathematical science; because the science of wealth being the science of the phenomena relating to the quality which constitutes things wealth, and it being agreed that exchangeability is the quality which is the essence of wealth, the science of wealth can be nothing else than the science of exchanges, or the science which treats of the laws which govern the varying exchangeable relations of these diverse quantities.

The picture of economic unanimity through so many centuries of antiquity is so rare and so delightful, that I must linger over it yet a little while before we embark on the stormy sea of modern economics. I wish with all my heart that we could enter and take possession of our science. But that cannot be yet. Like as when the children of Israel had come in sight of the Promised Land they were sent back to wander many a year in the desert, and only obtained possession of their inheritance at last after years of misery, of battle, bloodshed, and slaughter, so we cannot yet enter into our possession. We must wander through many a weary century of human folly, misery, and wretchedness, through interminable wars, and disputes, and controversies, before we can take possession of our inheritance. But yet I think it well to place before you the goal we have in prospect, for the ideas of the ancients which I have laid before you are those to which I shall lead you back at last, and these are the haven where, in all future ages, the souls of economists will have rest.

And now we must bid adieu for the present to those halcyon days when the whole world was of one mind with respect to wealth and value, and, like as in a play, we must suppose a long interval to elapse. But I must pass rapidly over the ideas of many centuries, because the general outline is known to all. For many centuries it was held that gold and silver were the only wealth, and the legislation of every country in Europe was directed as much as possible to encourage the importation of gold and silver, and to prevent their exportation. And from this notion it naturally followed that it came to be thought that what one side gained in commerce the other lost, which was the origin of the mercantile system, which was the cause of most European wars for several hundred years. And this shows you how necessary it is to understand economics to comprehend modern history. However, about the end of the 17th century it came to be seen that it was absurd to restrict the term wealth to gold and silver only, and it was enlarged to mean all the products of the earth which are useful to men. During all this time there was no such thing as a science of economics; a few sagacious writers perceived the fallacy of the prevailing system, but they were solitary lights shining in darkness, and the darkness comprehended them not.

Political economy took its rise as a science in the middle of the 18th century in France. That country had been brought to the lowest state of depression and misery by the ruinous wars of Lewis XIV., the financial catastrophe of John Law's Mississipi scheme, the prevailing mercantile system, the oppression of the nobility, and the weight of the taxes. It was in brooding over the intolerable misery under which their country groaned that a few righteous philosophers struck out the idea that there must be some natural science, some principles of eternal truth with regard to the social relations of mankind, the violation of which were the causes of that hideous misery they saw around them. Quesnez, the physician to Louis XV., was the great father of the sect of philosophers who were called the economists, and their object was to discover and lay down an abstract science of the natural rights of men in all their social relations; their relations towards the Government, towards each other, and towards property. The aggregate of sciences they termed political economy. This sect of philosophers being greatly favoured by Louis XV., acquired great celebrity, and since then it has been recognised that there is a distinct science of political economy.

The part of their science which related to property the economists designated the "production, distribution, and consumption of wealth;" and I must now explain to you the true and original meaning of this phrase, because it has been quite misconceived by recent writers, who constantly repeat it without having any idea of its true meaning. The expression then, "production, distribution, and consumption of wealth," as used by its originators, was one and indivisible, and meant the commerce or the exchange of the material products of the earth, and those only; or it meant the theory of the value of the material products of the earth.

As it may not be very apparent to you at first sight how the expression production, distribution, and consumption of wealth meant the theory of the value of the material products of the earth, I must explain to you the meaning of each separate term, when it will be seen quite plainly. And first I must explain to you what they meant by wealth.

They held that all things necessary for the preservation and comfort of the human race are products of the earth. These products which the producers used and consumed themselves they called *biens*, or goods; those only which they brought into commerce and exchanged they called *richesses*, or wealth. It is absolutely essential to understand the whole science of economics, for you to remember distinctly that the first school of economists expressly restricted the term wealth to the products of the earth which were brought into commerce and exchanged. Thus, again, we see that the principle of wealth was held to reside in exchangeability; but

only in material products. The economists expressly excluded labour and rights from the term wealth, because they said, to admit labour and rights to be wealth, would be to admit that wealth can be created out of nothing. It was their fundamental dogma that the earth is the sole source of wealth, because, as they repeated a multitude of times, man can create nothing; and nothing can come out of nothing.

I have now to explain what they meant by "production, distribution, and consumption." By production they meant obtaining the raw produce from the earth and bringing it into the market, or into commerce; but as this raw produce is scarcely ever in a fit state or fit position to be used by man, it has to be manufactured and transported from place to place, and, perhaps, sold and re-sold several times before it is finally used. All these intermediate processes which took place between the original producers and the ultimate consumers, the economists termed traffic or distribution.

The person who ultimately purchased the products so fashioned for his own use and enjoyment was termed *acheteur-consommateur*—the buyer-consumer—because this was the consummation or completion of the transaction.

The complete passage of the product from the original producer to the ultimate consumer, or customer, the economists termed commerce, or exchange; and, as originally any person who wished to consume or purchase any product must have some product of his own to give to purchase it, he also was a producer in his turn. Hence, in an exchange, things are consumed, or purchased, on each side. An exchange has only two essential terms, a producer and a consumer. These are the only two parties necessary to commerce. Hence, it is now seen clearly that the original meaning of the expression production, distribution, and consumption of wealth meant the commerce or the exchange of the material products of the earth.

To take a very simple example. The farmer grows the corn and brings it into the market. He is the producer. He sells it to the miller, who grinds it into flour, and sells it to the baker. The baker bakes the flour into the bread, and sells it to his customers. The sale of the corn to the miller, and the sale of the flour to the baker, the economists called distribution. The sale of the bread to the buyer was consumption. The word distribution was often used as equivalent to consumption. If a person wants to have anything distributed to him he must have something to give in exchange for it. Hence we see that the expression production, distribution, and consumption, is one and indivisible; also that "production and consumption" and "production and distribution" mean exactly the same thing. Each of these expressions meant simply exchange, and every act of exchange is a phenomenon of value. It is most important for you to remember that these two expressions were declared to be absolutely identical by their originators.

For certain reasons, too long to detail here, the school of the economists died out, and was superseded by that of Adam Smith, who published his work on the "Wealth of Nations," in 1776. Unfortunately, he never gives us any clear idea of what he means by the word "wealth." In his introduction he speaks of the annual produce of the land and labour of the society as its real wealth, and, from the number of times he repeats this phrase, it may be supposed that is what he meant, especially as it was a phrase in very common use. The slightest consideration will show that such a term is quite unfit to be used as a scientific definition of wealth. In the first place, you will see that he has omitted the condition of exchangeability, and thus has completely lost sight of the distinction made by the first school of economists between the products which were consumed at home and those brought into commerce and exchanged. Moreover, the objections to such a definition of wealth are so palpable, that I need not enlarge upon them, because if it be laid down absolutely that the annual produce of land and labour is wealth, then every useless work done would be wealth. If a lot of dirty children were diligently occupied in making mud pies, which are certainly the produce of land and labour, they would be augmenting the wealth of the country.

The objections to such a definition are so great that I need not dwell upon them. But I will show you the further inconsistencies into which Smith is betrayed, for he expressly includes the natural and acquired abilities of the people as fixed capital and part of the wealth of the nation. Now human abilities are certainly not the "annual produce of land and labour." Hence you will see that Smith expressly includes labour under the title of wealth, and the whole of the second school of economists agree in this. They specifically designate labour as a commodity, and treat of the laws which govern its value, just as that of any material chattel. In this you will observe that they agree with the dialogue I have already quoted to you as proving that labour is wealth, because it can be bought and sold. And in this the second school of economists are undoubtedly right. Labour is an exchangeable commodity. It has value: and the laws of its value are exactly the same as those of any material commodity. In point of science, therefore, the second school of economists are right. But then it is a very awkward matter for the definition of the science, because how are we to speak of the production, distribution, and consumption of labour? Who would readily understand such an expression? Whereas it is quite usual and intelligible to speak of the supply and demand of labour. But you will remember that the economists expressly excluded labour from the title of wealth, as I explained to you; and the expression, production, distribution, and consumption of wealth, was expressly framed to exclude labour from the term wealth. Thus you see that Smith and the second school of economists have already broken away from the nomenclature of the first school, and thus have given the fundamental conception of the science, the production, distribution, and consumption of wealth, a very awkward wrench; but still worse remains behind, because under the title circulating capital, Smith expressly includes bank notes, bills of exchange, &c., and the whole second school of economists agree in this. Now, what are bank notes, bills of exchange, &c.? They are nothing but abstract rights; they are what is called credit; and thus you see that the whole second school of economists include credit under the title of capital. But I have already

shown you that the whole body of Roman and Greek jurists expressly include rights of all sorts under the terms *pecunia*, *res*, *bona*, *merx*. Thus you see that the whole of the second school of economists expressly admit the three distinct orders of quantities to be wealth, which I have shown you were pointed out by ancient writers, material products, labour and rights.

Now, are these circulating rights, such as bills of exchange and bank notes, which are credit or debts, the annual produce of land and labour? It would be absurd to say so; thus you see that when Smith begins by filling the minds of his readers with the notion that wealth is the annual produce of land and labour, and when he ends by telling us that bank notes and bills of exchange, mere abstract rights, are wealth, the two notions are quite incongruous and self-contradictory. Moreover, Smith, after diligently inculcating on his readers for several hundred pages that the absolute produce of land and labour is wealth, in speaking of a guinea, which is undoubtedly the produce of land and labour, says:—"If it could be exchanged for nothing, it would, like a bill upon a bankrupt, be of no more value than the most useless piece of paper." Thus you see that Smith at last comes to exchangeability as the true essence and principle of value. Thus you see that the ideas at the beginning of the book are quite incongruous with those at the end. He begins by making the essence and principle of wealth to be in labour and materiality, and he ends by making the essence and principle of wealth to be exchangeability pure and simple. Now, admitting all the services he has done, these glaring contradictions are a fatal defect in it as a scientific treatise.

Smith emanated from the first school of economists, and he understood the true meaning of the term they originated. He calls his first book "On Production and Distribution," but he expressly says that its purpose is to investigate the principles which regulate the exchangeable value of commodities. It is, therefore, in its nature, a treatise on Value or Commerce; and McCulloch, in the very first page of his edition of Smith, says that political economy might be called the science of values. Ricardo calls his work "The Principles of Political Economy and Taxation," but the part of it relating to political economy is nothing but a treatise on prices, that is, value.

The last writer whom I think necessary to cite is Mill, from whom, as a professed logician, we should naturally expect more consistency, though in this we shall unfortunately be disappointed. In his "Logic" he carefully inculcates the necessity of accurate fundamental conceptions in science; we might naturally expect therefore that he would be particularly careful in settling the fundamental conception of political economy, and give an example of his own doctrine that the moral sciences are to be constructed in the same manner as the physical sciences.

We are rather surprised, therefore, to read on his first page, "Everyone has a notion sufficiently correct for common purposes of what is meant by wealth;" but is that a fact? We have already seen the stupendous importance in the history of the world of the meaning of the word wealth; we have also seen the inconsistencies of Smith, and we are therefore somewhat surprised to read in Mill, "It is no part of the design of this treatise to aim at metaphysical nicety of definition when the ideas suggested by a term are already as determinate as practical purposes require." But is the definition of wealth already as determinate as practical purposes require?

A little further on, however, we have this expression, "Everything forms, therefore, a part of wealth which has power of purchasing." Here we have a clear and definite definition of wealth, exactly agreeing with Aristotle and all ancient writers, which manifestly includes all the three orders of exchangeable quantities, material products, labour, and rights. In this passage Mill makes exchangeability the sole essence and principle of wealth, and, accordingly, the production of wealth is simply the production of anything which is exchangeable. Now, having got this definition, we might have expected that all controversies were at an end; and as the essence of wealth is exchangeability, the science of wealth can be nothing but the science of exchanges.

Reading a few pages on, we come to the passage, "The production of wealth—the extraction of the instruments of human enjoyment from the materials of the globe." Now, here Mill has completely changed his conception of wealth. Here, he makes it all extracted from the materials of the globe; it is merely the instrument of human enjoyment, and all trace of exchangeability has vanished from the definition. These two passages manifestly betray the same inconsistency as I have already pointed out in Smith, and we are relegated to economic darkness. Again, somewhat further on, he says:—"I shall, therefore, in this treatise, when speaking of wealth, understand by it only what is called material wealth;" but on the very same page he says:—"The skill, and the energy, and perseverance of the artisans of a country are reckoned part of its wealth, no less than their tools and machinery." And if the skill and energy of artisans are part of the wealth of a country, why are not the skill and energy of other persons besides artisans? But thus you see that Mill expressly acknowledges skill, and energy, and ability to be wealth; and is skill and energy material, and is it extracted from the materials of the globe?

Further on, however, he expressly classes credit under the title of wealth. For he begins by saying that everything which has purchasing power is wealth. He then says "Credit, though it is not productive power, is purchasing power;" also "The credit which we are are now considering as a distinct purchasing power;" again, "The amount of purchasing power which a person can exercise is composed of all the money in his possession, or due to him, and of all his credit." "Credit, in short, has exactly the same purchasing power with money."

Now if Mill expressly defines wealth to be anything which has a purchasing power, and if he expressly says that credit is purchasing power, then the inevitable conclusion is that credit is wealth.

That is a syllogism in which Mill is safely padlocked, and from neither he himself nor all the logicians in the world can deliver him. He also says:—"An order, or note of hand, or bill payable at sight for an ounce of gold, while the credit of

the giver is unimpaired, is worth neither more nor less than the gold itself." And he also classes bank notes under the title, productive capital. Now, let me ask, are credit and orders for the payment of money, and bank notes, extracted from the materials of the globe?

Now, I must tell you that I have far from exhausted Mill's self-contradictions on the term wealth, though I fear I have exhausted your patience. And let me ask in sober seriousness, after even such a picture as I have presented to you, what do you think of Mill's assertion that everyone has a sufficiently correct notion of what is meant by wealth? Has he himself any clear or correct idea of it?

Now, after this amazing and almost incredible confusion and contradiction in the very word which is the basis of the whole science, can you wonder at the pitiable state in which the so-called science of political economy is in the present day? And the specimen I have given you is in reality a brick from the whole house. For the very same contradiction and confusion as to every other leading term in the science prevails in the two most popular works I have alluded to.

I must now give a few words to point out a glaring defect of this school of economists. I have shown you that they all admit that bank notes are productive capital. But bank notes and bills of exchange are mere rights of action recorded on paper, and they are only variety of an enormous mass of rights of diverse sorts which are bought and sold, and which receive different names according to the source from which they spring. Thus, when a trader has established a successful business, he can sell the good-will of the business. The good will is a saleable commodity quite separate from the buildings or the goods in a shop. It was said in the papers that when the eminent banking house of Jones, Loyd, and Co., sold their business to the London and Westminster Bank, they received £500,000 for it; now that good-will could not be seen or handled, but it could be sold; it had value; it was mere right, and yet it had exaetly the same value as so much corn or timber, or any material chattel. In exactly the same way every house of business has a good-will over and above the material goods in the shop. So there are other varieties of rights, such as copyrights, patents, shares in commercial companies of all sorts, and others amounting in value to something which is absolutely inconceivable in this great commercial country, and yet of this class of valuable property there is not one single word in any of these books on political economy. Now, is this colossal mass of rights of various sorts the produce of land and labour, or is it extracted from the material of the globe?

All this class of property is, as I have shown you, expressly classed under the term *pecunia*, *res*, *bona*, and *merx*, in Roman law, and under that of χρήματα, in Greek law, and in English law, under that of "goods and chattels," or vendible, and in recent time has increased at an enormously greater ratio than material property in this country; and yet, with the single exception of such rights of action, or bank notes and bills of exchange, it is totally omitted by the common writers on political economy as if they were ignorant of its existence.

The most colossal branch of commerce in the country, namely banking, consists exclusively in creating, buying, and selling rights of action called credit; and these various forms of credit, as has indeed been observed, act upon price exactly in the same way as so much gold. Some ingenious persons estimate the effects of gold on prices, but it is too often forgotten that it is not only gold and silver which affect prices, but gold, silver, and credit; and very few have any idea of the enormously greater quantity of credit there is in this country than gold and silver. All such estimates must of course be very rough, but I will give one statement which may perhaps help us to form a true idea. I believe that some authorities estimate that there are almost £120,000,000 of gold coin in the country. Now, there is an interesting table presented to the House of Commons by Mr. Slater, and he found by the examination of his books that in one year out of every million of payments by his house only £10,000 were made in gold coin; and out of every million of receipts only £28,000 were made in coin; that is out of the total less than 2 per cent. were made in coin; all the rest were made in credits of different forms. Now, I think that statement furnishes us with a clue by which we can form some approximate idea of the ratio of coin to credit in this country. If, then, the gold coin be estimated at £120,000,000, and is only about 2 per cent. of the credit, that would make the different forms of credit amount to almost £6,000,000. An eminent authority has calculated that the bank credits in the whole United Kingdom amount to about £800,000,000; and are all these the produce of land and labour, or extracted from the materials of the globe?

Fifty years ago, Mr. Justice Byles observed that the value of the property in bills of exchange alone was only second to that of the land and the funds; at the present day, there can be no doubt that the value of the bills of exchange in this country far exceeds that of the funds.

You now perceive mischievous consequences of that contradiction and confusion between labour and materiality and pure exchangeability as the essence and principle of wealth and value which pervades works of the second school of economists. How is this vast mass of saleable property the produce of land and labour? Whereas, when we adopt exchangeability as the sole essence of wealth, it is perfectly clear.

I have now said enough to indicate to you the fundamental and radical objection to that school of economists who adopt production, distribution, and consumption of wealth, or some variation of it, as the definition of the science. They have, in fact, totally lost sight of and forgotten the true and original meaning of the expression, as explained by the persons who originated it. They have totally forgotten that the first economists only admitted the material products of the earth, which are exchanged, to be wealth, and that the production, distribution, and consumption of wealth meant exclusively the commerce and exchange of those material products.

The first economists expressly excluded labour and rights from the term wealth, but the second school unanimously admit labour and rights. Now the expression production, distribution, and consumption of wealth, which is a perfectly intelligible term when restricted to the exchange of the

material products of the earth, becomes absolutely unintelligible when applied to the commerce and exchanges of labour and rights; and thus the second school of economists, by introducing labour and rights into the definition of the science, have shattered the whole framework of their system in hopeless and irretrievable ruin: and the labours of the two preceding schools have only ended where Aristotle began.

But now let us adopt the alternative and equivalent expression, namely, that of commerce or exchanges, and it is like the transformation scene in a pantomime, where everything was incomprehensible chaos, like as from the stroke of the enchanter's wand, it settles into harmony and order.

In the very same year that Smith published his "Wealth of Nations," 1776, the well-known French economist, Condillac, published a work entitled "Le Commerce et la Gouvernement." The plan of this work is identical with that of Adam Smith. Each commences by an exposition of the theory of value or of commerce; Smith calls this division of his work the production and distribution, but I have already shown you that the true and original meaning of this phrase is exchange. Condillac at once commences by defining economic science to be the science of commerce. While Smith's work attained immediate popularity, Condillac's was forgotten amid the crash of the French Revolution. But there has always been a line of writers who perceived that commerce or exchange is the true definition of political economy. I can only mention Whately, who enforced this view at Oxford in 1831. Bastial, the most brilliant writer who ever adorned the science, says—"Exchange is political economy." "It is the exchange of services which is the subject-matter of political economy; economic science is comprised in the word value, of which it is the long explanation." I am sure you will permit me to mention that when, 22 years ago, I first published a treatise on political economy, adopting exchange as its fundamental conception, M. Michel Chevalier, the most distinguished professor in Europe, immediately expressed to me his approval of it; and in 1862 presented a report to the Institute of France, declaring his entire adhesion to my views; and since I have published a greatly enlarged edition of it, he has adopted it as his text-book of political economy at the College de France, and writes to me, "It is your book which serves me as the guide for all the philosophy of my teaching at the College de France."

In 1863, M. Rouher, one of the most eminent economists in France, who was the leading minister who negociated the commercial treaty between England and France, and who was then Minister of Agriculture and Commerce, directed one of the chiefs of departments to draw up an account of my system in a volume, which he ordered to be distributed to all the Chambers of Commerce in France. The most recent economists in America have adopted the same view. I have here the 16th edition of a work by Professor Perry, of Williams College, Massachusetts, the most eminent of American economists, based upon this definition. He says, "Political economy is the science of exchanges, or what is exactly equivalent, the science of value." "Wherever value goes, this science goes; wherever value stops, this science stops." And I might mention a large array of writers in recent times who have adopted the view that pure economics is the science of exchanges.

I will now give a few examples to illustrate the difference between the expressions—production, distribution, and consumption, and exchange. Suppose a person has a piece of land upon which the other persons want to build houses; the land rises greatly in value; the owner sells the land; that is an exchange and a phenomena of value, but how is it the production, distribution, and consumption of wealth?

An author writes a popular work; he can sell the copyright to a publisher, that is an exchange and an instance of value; but how is it the production, distribution, and consumption of wealth?

Two persons agree to do some work for each other; that is an exchange and an instance of value; but how is it the production, distribution, and consumption of wealth?

A banker discounts a bill for a customer by giving him a credit in his books; that is an exchange and an instance of value; but how is it the production, distribution, and consumption of wealth?

These few examples, which might be multiplied to any extent, serve to illustrate the superiority of the definition of exchange. Thus you see that the expression production, distribution, and consumption of wealth, was expressly restricted to the exchange of one class of commodities, only the material products of the earth, while the expression science of exchanges, means the theory of value or commerce, and includes all exchangeable quantities, and all exchanges of every form and variety. By adopting this definition, we at once see how political economy or economics, is a physical science. What is there in the name production, distribution, and consumption of wealth to suggest any resemblance to a physical science? But, as soon as we adopt the alternative and equivalent definition of the science of exchanges, we see at once how it is a physical science. Because we have a distinct body of phenomena all relating to a single quality, a body of particulars fixed and circumscribed by a definition, and therefore fitted to form a great demonstrative science, of the same rank as mechanics, or optics, or any other physical science. Because, there being three orders of exchangeable quantities, and therefore six species of exchanges, the object of the science is to determine the laws of the phenomena of these exchanges — that is, the numerical relations of these quantities; and, as there is a single general law which governs the motions of the heavenly bodies, it is perfectly easy to show that there is a single general law which governs all the changes in the numerical relations of exchangeable quantities.

Thus the great science of exchanges or of commerce, in its widest extent, is clearly seen to be a physical science; but it is also a moral science because it is based upon the mores of men. For we find that the same general laws of exchange hold good among all nations, among the rudest and the most civilised in all ages and countries; and that is the reason why economics may be raised to the rank of an exact science; a permanent and

universal science of the same nature as the physical ones, because it is based upon principles of human nature which are found to be as permanent and universal as those of physical substances upon which physical sciences are based. And, therefore, it is a physical and a moral science, and the only moral science which is capable of being raised to the rank of an exact science.

DISCUSSION.

Mr. Shepheard said this was, no doubt, a very interesting paper, but he feared that in some points it would tend to increase the doubts which students felt on the subject, instead of clearing them away. All he knew of political economy was derived from the very works referred to—from Adam Smith, Stuart Mill, Ricardo, Jevons, and others, and he must confess that the definition of wealth had always been a difficulty, and it did not suggest any other idea then this, that if you had a product which was the resultant of several factors, whether you should call one or the other of the factors by the definition or term of the science. He found an interpretation which made Mill's treatise a satisfying one. It was this, to consider wealth as the product of land and labour; by land, including all natural forces, and by labour, all that man contributed to the product—his skill, energy, and physical force. In this way, he thought that students of political economy must get over the inherent difficulty which they felt in the definition of wealth. As he understood the paper, they were to transfer the term wealth to exchangeability, and every political economist had felt that difficulty. Ricardo said they ought to call it the science of catalaetics; but that was a difficult name, and was therefore not adopted. A little confusion which he thought might arise from the paper was this. He thought Mr. Macleod treated wealth without alluding to those careful subdivisions referred to in all economical treatises, viz., wealth to the world, wealth to the nation, and wealth to the individual. If, as the result of land and labour, a house were erected which did not exist before, that added to the wealth of the world, and also to the wealth of the nation in which it existed. The mere right of transferring the house from one person to another did not double its wealth. It was the subject matter of the transfer which was the real wealth, and whether he had a piece of paper which enabled him to hand it to anybody else, or a bill or order, which enabled him to obtain gold from anybody else, the economist had, he thought, rightly considered the material production the real wealth, and that the exchangeable paper was merely the transfer of the wealth from one person to another. They did not add to or create wealth. He ventured to think that this paper, without some explanation, would be very perplexing to the students of economic science, and he would ask students to retain that leading notion that wealth was the product of land and labour, and if they did this they would steer through many difficulties in the science, and be able to observe those truthful divisions, the production, distribution, and exchange of wealth.

Mr. Elliot said the last speaker objected to the term wealth being restricted to exchangeability, and applied it to the product of land and labour, referring to a house as an addition to the wealth of the world. Now, a house was wealth to the man who built it to live in; but what wealth was the house to dwellers in tents? They did not want it, and, therefore, how could it be wealth at all?

Mr. Creighton Macleod said anybody who had listened to the paper would have heard that the definition of wealth as the product of land and labour would not do at all. Mr. Macleod showed that some things which were the production of land and labour clearly were not wealth, and instanced mud pies, which clearly showed that the definition would not do at all. Again, what right had you to say that land meant all natural forces? You would not find that definition in any dictionary, and an ordinary reader would not understand it at all. Mr. Shepheard seemed to think that all useful things were an addition to the wealth of the world. Now anything might be useful, but it was not the subject of political economy until it became the subject of exchange and sold in the market. The pictures in the house of a nobleman were not wealth until they come into the market. He did not seem to understand the distinction which was drawn between "*biens*" and wealth. "*Biens*" were goods which were themselves useful and beneficial, but wealth were things which could be exchanged.

Mr. Paterson said, as he understood the paper, it proposed to restrict the science of economy to the science of exchange, and he did not see how they could escape accepting Mr Macleod's definition of exchange as the central idea of the science. It had always seemed to him that the former school of economists were not quite agreed as to what the central idea of their science was. Some seemed to think that political economy meant the science of wealth in the sense in which things were good for human beings, and tending to their welfare. This would make it a much larger science, and would make it more Mr. Ingram's idea of it, as the science of sociology. It would be a much more valuable science than that of mere exchange, but would include a greater number of elements. The reason why Mr. Mill was inconsistent was that he did not limit himself to the groundwork of his science, but treated it partly as the science limited to exchange value, and partly as the science of general well-being. But take it as the science of exchange, and also as the science of uses of wealth, it could not be denied that debts or claims were really capital, in the sense that they were a power of selling and purchasing by setting labour in motion. It must be quite clear that the power of drawing on a solvent man, the power of credit which did not represent any material object, was yet a power of employing labour. For instance, if you had 100 men — carpenters and bricklayers — out of employment, and if a man who possessed nothing but credit had sufficient to put these men in motion, and produce some utility, embodied in the form of a house which was wanted, then this credit was an economical force, being the force which went to put the labour in motion. Mr. Mill himself had pointed out, when speaking of bills, as to the notion of accommodation bills being false things, and bills founded on real transaction being true, that there was really no difference between an accommodation bill, if the people concerned were honest and solvent, and one founded on a real transactions, because if A sold B £100 of goods, and the goods were transferred, and A got a bill at three months, and B did not keep the goods, they did not form the basis on which the bill was given, and he transferred them within the three months to somebody else, and probably got another bill for them. Yet those two bills came into the market, and affected price. He had been for a long time a reader of Mr. Macleod's books, and admired his great originality, but it seemed to him that, if you narrowed the science of political economy to a mere science of exchange, you met this difficulty. Value of anything was simply a mental quantity, so that any particular object had no value to anybody but just the value resulting from the desire a person had for it. Now, we had no means of measuring the mental states of men, and it seemed to him you might say price represented a certain fluctuation in men's attitude towards certain things, and when you had said that you had said all for the science. The science, although it would be an exact science as far as it went, would lead you to nothing in the direction in which he should say political economy ought, namely, in directing and guiding human action in the

production and distribution of wealth toward that which was best for human welfare. The science of price alone would, he thought, be so uninteresting that no one would care to pursue it.

Mr. Bain thought the paper had omitted to deal with the fact of supply and demand. They all knew there were things which had been of comparatively little value, seemingly, and yet after a time a demand had sprung up, and their value had increased enormously, and so added to the wealth of the individual, and no doubt of the country too. Sometimes demand stimulated supply, and sometimes supply stimulated demand. He knew of an article which at one time was sold at 6s. per ton, and a few years after was sold at 84s. He therefore thought there was something more to be looked to than the mere word exchange.

The Chairman thought wealth might be defined as anything which could be exchanged to supply the wants of man. Gold, to a man in the desert, if he had a camel-load of it, would not be wealth, because he would starve if he had nothing else. In the same manner, if a ship were on her way home laden with gold, and were short of water, if the owner were on board, the gold would not be wealth to him, because he could never use it, and he and his gold would perish. The subject was very vast, and if one began to talk upon it, one would soon drift into a very long discussion, and he would, therefore, ask Mr. Macleod to reply to the observations which had been made.

Mr. Macleod said he did not think there was really much to answer. Mr. Shepheard said wealth was the produce of land and labour; Adam Smith said it was the produce of land and labour; but he also said that human abilities were wealth, and that bank notes were wealth; and he wanted to point out that these definitions were inconsistent, because human abilities and bank notes were certainly not the produce of land and labour. If you began to discuss this subject, it was like the letting out of waters, and he had, therefore, endeavoured to confine his remarks to as narrow a compass as possible. The people who invented the term political economy applied it to what was called sociology; it was applied to all the relations of man—to themselves, to government, and to property; it was J. B. Say who first restricted the term to the production, distribution, and consumption of wealth, because he said it could be produced and consumed wholly independent of forms of Government. It was only when restricted to the production and distribution of wealth that he said the definition was obscure, and only intended to apply to one class of wealth, whereas the definition of exchange was perfectly clear, and comprehended all commodities. That was why there was a general revolt against the term political economy, and everybody wanted to get rid of it. In a little book which Mr. Gladstone had lately published, on Homer, he called it a most misguiding expression. Mr. Shepheard said that Ricardo called it catalactics, but that was a mistake, it was Whately who first gave it that name. That, no doubt, was a good name, but it was difficult to change a name when once understood, and was unnecessary when there was a simple English word which answered the purpose. Some people wanted to call it the science of wealth, and that was why he dropped the name political economy and adopted that of economics. It was sometimes said that *oikos* was the Greek name for a house, and that the *oikonomos* was the master of a house, and that economy would make people wealthy. But the Greek word *oikos* meant any kind of property; it was the technical word in Attic law for what in English law were called a man's property and estate; not only lands and houses, but bills of exchange, and so on, were included. Therefore the science of economics was the science of exchange of all kinds of property. When you adopted the exchangeability as the basis, you got a grand science, because exchange was a quality common to a great variety of different things. The exchange of these different things constituted commerce in its widest extent. To go properly into the subject would require a long discussion of various abstract rights, and to point out the difference between a bill of exchange, which was a mere abstract right, and a bill of lading, which was a title to certain particular things, and banking credits, and so on. Any person who knew anything about business, knew that banking did not consist in borrowing and lending money, but in creating rights of action. The banker had so much money deposited with him, and in exchange for that he created rights of action. People offered him bills for discount, and he bought those bills by creating other rights of action; those actions were called deposits. The deposit in a bank was not the money or the bill of exchange deposited, but the credit created by the banker to buy those deposits. Deposits were the banker's liabilities, and they were the price he paid for his assets. In modern times, those liabilities or banking credits were the great circulating medium of the country, money was used to a very small extent indeed; commerce was carried on exclusively by these banking credits. The great fault of economists was that their works were founded on two contradictory principles; in one part of their books they laid down the principle that wealth was the product of land and labour, and in another that wealth consisted of exchangeability. It was the ideas of exchangeability alone which would resolve all these difficulties, and explain that gigantic trade in rights of action which was the modern system. It was a distinct body of phenomena, separate from all others, which formed the science of pure economics; poor laws and all that kind of thing ought to be called mixed economics, not being the subject of fixed scientific laws; but the science of economics was subject to the same general laws as the science of astronomy. One gentleman said he had not gone sufficiently into the subject of supply and demand, and that was quite true, simply because he had not sufficient time. Demand, or wants and desires, were the sole origin of value, and all changes in value arose out of changes in the intensity of demand and the limitation of supply. You never had any change of price and value without some change either in the intensity of demand or the limitation of supply. But that was a step further than he wanted to go. He only desired to trace the outlines of a great science which could be prosecuted further.

The Chairman then proposed a vote of thanks to Mr. Macleod, which was carried unanimously, and the meeting separated.

CANTOR LECTURES.

MATHEMATICAL INSTRUMENTS.

By W. Mattieu Williams.

Lecture IV.—Delivered Monday, Dec. 16th, 1878.

In the last lecture, some of the instruments for measuring straight lines were described, but the best of these are liable to considerable error. One of the chief sources of error in ordinary land measurement is the irregularity of the ground. The chain or tape must either lie upon the ground and follow its ups and downs, or it must be stretched across the hollows. This stretching, however, does not rectify the curves, for however severely a chain, or cord, or tape may be stretched, it cannot be drawn straight. Its own gravitation

always bends it downwards between the points of suspension, and causes it to describe a peculiar curve, to which the name of "catenary," or "chain curve," has been given.

As we cannot stretch a chain straight across a valley, over a river, or from peak to peak of mountains, how are we to measure the length of straight lines in such positions?

This problem is solved by the fact that nature provides a practical infinity of such straight lines stretching in every unobstructed direction. These are the rays of light which are continuously thrown off from every visible object. If we can devise a means of measuring them they are incomparably better than any sort of chain, or bar, or tape, or other such mechanical measure. Not only do they supply us with straight lines when unobstructed, but we get these lines drawn directly from the objects to our eyes, even when the objects are otherwise inaccessible.

The problem then is, first, how to catch these rays, and then, having caught them, how to measure them.

First, as regards catching the rays. Here, as in the previous cases, we have to consider our own relations to the external world, or the conditions of sensation. We see objects by virtue of the action of these rays of light upon our optical apparatus (including our external eyes and inner cerebral organs of vision).

The visual position, or apparent direction of any object, is determined by the direction in which the rays of light proceeding from that object enter our eyes. If the rays come to us perpendicularly, the object appears overhead, if horizontally, it appears on our own level. We refer our sensations outwards according to the direction in which we receive them.

If rays of light were to proceed from *a* (Fig. 5)

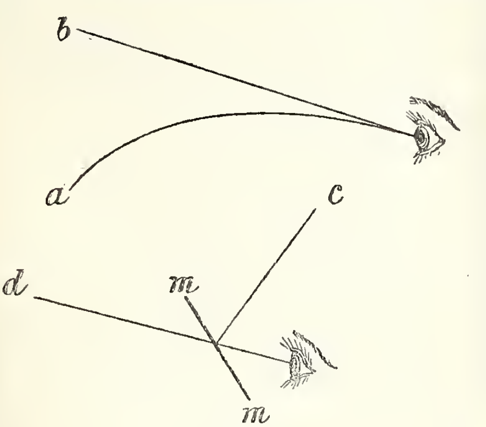

Fig. 5.

to the eye in the direction of the curved line, we should not see it in its true position at *a*, but it would appear to us to be situated at *b*. If rays proceeding from *c* were to be reflected by a mirror, and thence received by the eye, we should see the object at *d* behind the mirror.

Rays of light are thus bent and reflected when they encounter obstructions, such as variable transparent media or reflecting surfaces. As we shall presently see, the reflection may be turned to account to assist our measurement, but the bending or refraction introduces an element of error demanding correction. This is especially the case in astronomical measurements.

In ordinary terrestrial experience we are not usually deceived, but see objects in their true position by virtue of the rectilinear path of their rays. It is by means of this position that we may measure the length of the rays or the distance of the object from our eyes.

Let us suppose an object situated at the point or position C (Fig. 6); it is evident that when we

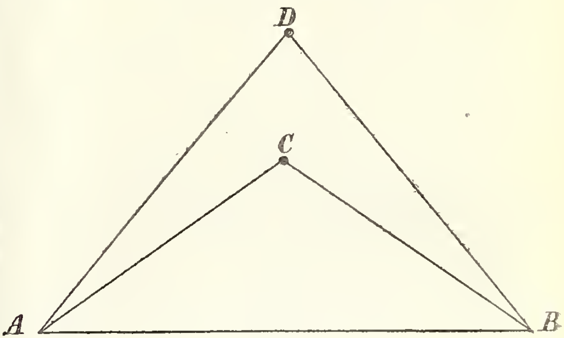

Fig. 6.

stand at A the rays of light which render it visible enter our eyes in quite a different direction, relative to the line A B, from those which render it visible when we stand at B. It is also evident that if we can measure the length of the line A B, and the angles which the rays make to it, we can construct the triangle A C B, or one that shall in all its proportions correspond to it; or better still, we may, by the aid of trigonometry, calculate the other elements of the triangle when one side and the two angles at the ends of that side are given. Such calculation is better than any construction, inasmuch as it is absolutely accurate.

In like manner, if we have another object, D, at greater distance, and we somehow catch the rays streaming from D to A and D to B, and determine the angle they make with our measured line A B, we can equally construct or calculate the triangle A D B, the sides A D, and D B, of which measure the distances of D from A and B.

It is also evident that we may do the same, even though the distance of D be much greater and inaccessible to mechanical measurement. It may, for example, be the lighthouse of Cape Grisnez, on the French coast, and the line A B may be drawn on the cliffs of Dover. The only sources of error in the measurement of the distance of the lighthouse by these means are errors in measuring A B, and the angles made to it by the rays from the lighthouse. There need be no error in completing the triangle according to these data.

Let us now consider another problem, the measurement of the height of a distant object such as the point C (Fig. 7).

By measuring the horizontal line, A B, and the vertical angles which the rays from C make with this line, we can complete the triangle, C A B, as before, and as the height demanded is a perpen-

dicular line from C to a continuation of A B, we now know all the angles of the triangle, C D A, as well as the length of its side, C A. From these it

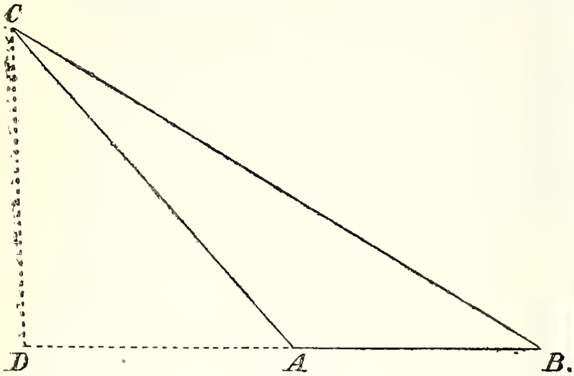

FIG. 7.

is easy to calculate the length of the dotted line, C D, *i.e.*, the height of the object, and also D A, its horizontal distance.

I shall presently describe the instruments by which we catch the rays, and determine their direction, but before doing so must say a little more concerning the measurement of A B, or the "base line." Any error in this must of necessity be communicated to all the other measurements. In spite of this it is found practically that a long line, such as across England, can be more accurately measured trigonometrically, *i.e.*, by building a series of light-ray triangles on one or more base lines, than by the direct application of a yard measure. Besides this the trigonometrical measurement of the light rays is incomparably easier than the measurement of the ground.

The Ordnance Survey of Great Britain has been conducted accordingly. Base lines have been measured with the greatest possible care on Hounslow-heath, Salisbury-plain, Romney-marsh, &c. The principal base line was measured in 1826 on the sands of the east side of Lough Foyle near Macgilligan. There is here a long stretch of beautiful hard level sand, commanding fine views of a number of the summits of the Donegal and Derry mountains, thus affording a fine series of primary triangles, the sides of which triangles serve as secondary base lines for further light-ray measurements extending across to the mountains of Scotland.

The first step towards the measurement of such a base line is the levelling of the ground, and drawing, by means of sights, the straight line to be measured.

That the drawing of a straight line along the ground from one point to another demands some care and skill, is easily tested by attempting to walk through snow (or other ground leaving foot-marks) directly from one object to another. If the goal alone is regarded, a curious track will probably be made. In order to walk straight to it, another and more distant object must be sighted, which is visually covered by the goal. A straight path is maintained by keeping it so covered all the way. The surveyor draws his straight line on this principle by means of continuously covering or coincident sights.

Metal bars are used for measuring. These must be compensated for variations of temperature, or their expansion and contraction corrected by calculation.

Compensated bars were used in 1826. They were of compound structure, as shown in Fig. 8,

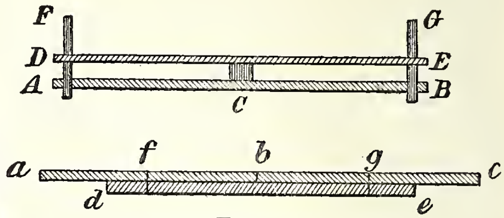

FIG. 8.

where A B is a brass bar, and D E an iron bar connected at C, and by the terminal tongues, F and G. Brass, when heated, expands more than iron in the proportion of 5 to 3. By making D F and G E three-fifths of F A; and G B, the ends of the tongues, on which are the determining lines or dots, will remain at the same distance apart, in spite of the expansion or contraction of the bars.

In applying these bars, the ends of the tongues are laid against the marked line, and the bar left lying. Then another bar is placed with A B on the other side of the line, and the dot or line on its tongue exactly coincident with that of the first, as shown by the aid of microscopes.

Another method is shown below, where end bars are used uncompensated, but in the use of which the temperature is carefully recorded and corrections made accordingly. It is found that in merely laying bars end to end, considerable errors arise from imperfection of contact, and the more frequently the operation of laying them is performed, the more liable is the operator to error. The most determined and strong minded of human beings becomes mathematically convicted of carelessness, when compelled to repeat, for a long time, a monotonous operation of this kind. Grains of sand, particles of dust, or small air spaces are allowed to interpose under such conditions. To prevent this a third or checking bar, *d e* is used, and the lines are marked on the middle of the measuring bars at *f* and *g*. The contact of the ends of the measuring bars is thus tested by the coincidence of their lines with those of the checking bar, which, of course, are originally adjusted to the proper distance between *f* and *g*. By one or other of these devices, and checking by remeasurement by repetition, base lines, of eight or ten miles long, have been measured within an error of a small fraction of an inch.

We now come to the instruments by which the angles made by the light rays to the base line are measured. There are many of them. I shall take the theodolite as the typical and most perfect instrument, and therefore give it the largest share of attention.

I assume that all present understand that angles are measured by making their starting point the centre of a circle, and measuring the arc or fraction of the circle which their boundary lines embrace; and also that the unit of such measurement is a degree, or the 360th part of a circle, which degree

is divided into 60 minutes, and the minutes into 60 seconds.

The theodolite may be described in general outline as a telescope, mounted on both a vertical and a horizontal axis, in such a manner that the partial or complete horizontal or vertical rotation of its optical axis may be measured in degrees of arc and their fractions. Thus the telescope is the optical instrument that catches the rays of light; its optical axis shows the line of their direction, and the fittings or framing of the telescope measure the inclination of this line to any given base line, or to a horizontal line.

There are many forms of theodolite, but to avoid confusion, I will, at present, only describe that which is most commonly used for ordinary surveying purposes, and which is portable.

As the measurement of horizontal angles is the most important function of such instruments, I will take the arrangements for this purpose first. A and B (Fig. 9) are two horizontal plates, the

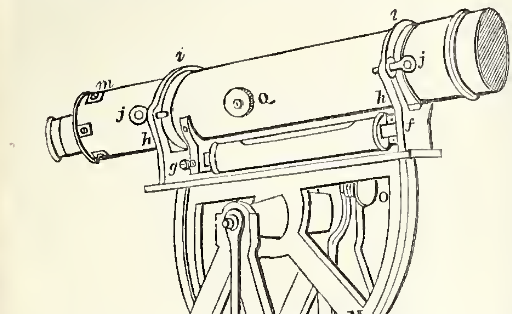

Fig. 9.

upper one (A) is flat, and the lower one (B) is thinned or dished internally, and to make room for a flange, &c., but has a raised rim, which is bevilled, as seen at B. The dished portion is covered entirely by A, which only bears upon the raised rim of B. B is called the "limb," A the "plate;" both together are sometimes described as the "horizontal limb," in which case A is called the "vernier plate," and B the "lower limb." I shall use the short shop names, plate and limb.

The sizes of theodolites are described according to the diameter of the limb, 4 inch, 5 inch, 6 inch, 8 inch, and so on. The limb is screwed by a flange (underneath, and not shown in the drawing) to a brass vertical axis or centre; this centre, C, passes through the collar of a clamp, *c*, where it may be fixed or loosened by the clamp screw, H. Below the collar it is turned down to smaller diameter, and works freely but firmly in a ball at D, between the "parallel plates," F G. When the clamp screw, H, is loosened, all that portion of the instrument above C turns freely in a horizontal circle. But this is not all, for the centre thus attached to the limb is hollow, and receives within it an inner centre of bell metal, which is screwed by a flange to the lower part of the plate. When the clamp screw, H, is tightened, the plate turns horizontally upon the now fixed limb, and carries with it all above the limb. Thus the telescope has two means of horizontal rotation, one moving on the fixed limb, and the other with limb and plate together. When this latter motion is required, the limb and plate are clamped together by a screw (not seen in the drawing). These sweeping rotations may be made by simply touching the telescope and pushing it round, but slow motions for delicate adjustments are also required. These are obtained by means of "tangent screws," one of which (that for moving the limb) is shown at I. The clamp collar which holds C has a tail, to which is fixed by a vertical axis a little ball, in which the tangent screw works. The plain part of the screw near the milled head, I, works in another ball similarly fixed to the parallel plate, F. (In the drawing this arrangement is not correctly shown; there should be no thread at the back part of the screw near I, and the screw should not go through the tail of the clamp itself, for the obvious reason that the rotatory movement of the clamp would strain the screw. Hence the balls on vertical axis above described).

The slow movement or final adjustment of the plate is obtained in a similar manner by a tangent screw, one ball of which is fixed with rotatory play to the limb, and the other to the plate. This is not seen in the drawing.

The chamfered edge of the limb is covered with a plate of silver, which is divided to degrees and fractions of degrees according to the size of the limb, and the plate has two short corresponding or continuing chamfers, one of which is shown at *a*, the other, *i.e.*, is on the opposite side, at just 180 degrees distance. These are also covered with sheet silver, and engraved as verniers to read the divisions on the limb. The magnifier, E, moves round the limb by working in a re-entering angle or slot under the rim, and is thus brought over one or the other of the verniers. In some instruments each vernier has a magnifier to itself. The principle of vernier reading will be described hereafter.

I have spoken of the movements of the plate and limb when turning on their respective centres as horizontal, but it is evident that such is not necessarily the case, and will not be the case unless the instrument is so fixed that their centres or axes are vertical.

This verticality of the centres, or horizontal rotation of the limb and plate, is obtained by parallel means of the plates, F G.

As already stated, the centre, or axis, of the limb works in a ball. The stem, or upper prolongation of this ball, is firmly screwed into the upper parallel plate, while the lower, or ball portion, works in the up-curving concavity of a socket in the lower parallel plate, G. The outside of this socket is shown at D.

The four parallel plate screws, with large milled heads, are screwed into sockets wedged into one of the plates, and their rounded prolongations beyond the head bear upon the other plate. Either plate may take the socket or the bearing; in the drawing the lower plate takes the socket. The opposite arrangement is now more common, and is shown in Fig. 10, which represents the modern Y theodolite.

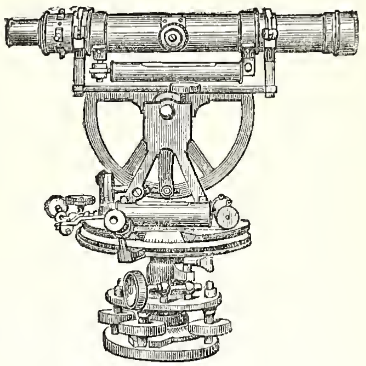

Fig. 10.

It may be easily seen that by means of these screws, the bubbles, *dd*, on the plate, may be brought to the centre of the tubes, and when this is the case, the plate and limb are horizontal, and their axis is vertical, provided the permanent adjustments presently to be described have been made.

The middle of the plate is occupied by a compass with divided ring, whereby the bearings of any object object to the magnetic meridian may be found.

The arrangements for measuring vertical angles are all above the plate. K and L (Fig. 9) are the "uprights" which support the horizontal axis of the semicircle or vertical limb, M. This semicircle is surmounted by an oblong flat piece of brass, the "stage," to the end of which are screwed the two Y's, *f g*, in which the bell-metal collars of the telescope rest, and are held in their places by the clips, *ii*, that are hinged on one side, and held down on the other by the pins, *j j*, in order that the telescope may be readily removed and replaced.

Under the telescope is a long spirit level, carefully constructed, by means of which the horizontality of the telescope is obtained, in order to determine the starting point for measuring its inclination from the horizon when moved upon the horizontal axis.

One side of the semicircle has an inlaid arc of silver, which is divided to degrees and fractions, and is read by the vernier *e*, which strides over the compass-box. N is the magnifier for this reading. On the opposite side to this magnifier is a clamp, grasping a portion of the axis between its bearing on the upright and its attachment to the semicircle. The milled head of the clamp screw is shown at O. This clamp has a tail reaching down to P, to which one ball of a tangent screw is attached, while the other works in the side of the upright. In directing the telescope upwards or downwards, this clamp is first loosened until the object is sighted, then the clamp is tightened, and by means of the tangent-screw the object is brought to its proper place in the field of vision.

We now come to the telescope itself, to which all the other devices are subservient. I have already spoken of this as the instrument that catches the ray whose direction we have to measure. Practically, we cannot operate upon a single ray, as through even the smallest pin-hole a countless multitude of rays can and do pour. A vastly greater number, of course, pour through the object glass of the telescope, the function of which is to converge all these rays to a point in the focus of the eye-piece, which is a microscope for the examination of the luminous picture thus obtained. The rays proceeding from the object-glass through the telescope thus form a cone of light, and what we want as the equivalent to our typical or fundamental ray is a line constituting the axis of that cone, or the optical axis of the telescope. If by any means we can get a line from the point of the cone straight through the optical centre of the object-glass, and on without deviation to the object under examination, we obtain the above-stated requirement.

This is effected by the device of "collimation." The collimator of a theodolite telescope is a circular diaphragm or plate of brass, with a hole about half an inch in diameter in its centre. It has a rim on its edge, and in this rim are the collimating screws, the heads of which are shown at *m*. As this collimator or "stop" is held by these screws, it is evident that by pulling one and pushing the opposite, the stop may be pulled towards one side or other of the tube.

Coincident with the diameter of the circular opening of this stop are stretched two spider webs, one vertical, the other horizontal. Of course they cross at the centre of the opening, but how are we to learn that this is the optical centre required?

It is determined thus. In the first place the drawer of the eye-piece is so adjusted that the spider-webs are clearly seen, in what is commonly termed its focus. Then a suitable object is selected (the instrument-maker uses a watch-dial nailed to the wall of an opposite neighbour's house), and the intersection of the spider lines is brought upon some clear well defined point of the object, and the telescope turned round on its collars in the Y's. If the point of intersection of the webs describes a circle during this turning, the collimation is defective, and the stop must be pulled by the collimating screws accordingly, until the point of intersection falls into the centre of that circle, so that on turning the telescope round again it only turns upon itself as its own centre.

We thus secure a coincidure of the optical axis of the telescope with the axis of the collars, *i.e.*, the line connecting their centres. This line (assuming the absence of atmospheric refraction) continues directly from the eye to the object, and thus the

optical direction of the telescope coincides with that of the central or typical ray whose direction we require to measure.*

As already stated, the level, *f g*, is used to determine the horizontality of the telescope, but, as now will be understood, it is not the outward and visible telescope, but the inner optical axis that has to be levelled. The level can only do this work when itself is parallel with that optical axis. This parallelism is attained by a special adjustment thus. Place the telescope roughly level by hand, then clamp the semicircle by turning the milled head, O; open the Y clips, *i i*, and then, by means of the tangent screw of the semicircle, bring the air bubble of the level to the centre of the tube; now lift the telescope from the Y's and reverse it, *i.e.*, place the collars in opposite Y's, taking care not to disturb the position of the semicircle. If the bubble remains in the centre of the tube, it must be parallel to the axis of the collars (which are of equal diameter), and being parallel to this, it is also parallel to the coincident optical axis; if not, the nuts at *f*, which raise and lower the level tube relatively to the telescope, must be turned till half the error is corrected, then correct the other half by the tangent screw, P, of the semicircle. This must be repeated by again and again reversing, &c., until the adjustment is perfect. The level should also be adjusted laterally, that it may be in the same vertical plane from end to end with the optical axis, as well as parallel below it. This adjustment is effected by means of the side screw of the "bubble-cock," and is tested by turning the telescope with the level a little on either side, to see whether the bubble travels in such positions. If this adjustment disturbs that of parallelism, the latter must be repeated. This being done, the bubble affords a horizontal zero from which any inclination of the telescope, upwards or downwards, may be measured.

We have yet to adjust the verticality of the vertical axis; or the horizontality of the plate and limb in relation to the optical axis, and thereby, to be assured that the bubbles, *d* and *d*, do their work accurately. To do this, set the instrument roughly level, clamp the axis of the limb by H, leaving the plate free, and move it till the telescope is over two of the parallel plate-screws; then bring the bubble under the telescope to the middle of its tube by the tangent screw, P; now turn the plate half round; then if the bubble returns to the middle, the limb and plate are horizontal in that direction; but if otherwise, half the difference must be corrected by the parallel plate-screws under the telescope, and half by turning the semicircle by means of the tangent screw, P. Now turn the plate 90 deg., or quarter round, backwards and forwards, so that the telescope may be over the other parallel plate-screws, and set its level by them. Having thus levelled the plate and limb by means of the telescope level, which, by the previous adjustments, now represents the horizontality of the optical axis, the levels on the plate *d* and *d* are to be adjusted by the screws at their ends, and thus the plate, the limb, and the telescope axis will harmonise.

These adjustments being made, the use of the theodolite is simple enough. 1st. To measure the horizontal angles made by the rays from any object to the base line, A B. Place the instrument over the end of the base line (say the terminal, or "bench mark," B) by means of the plummet supplied with the instrument, and which may be attached to the centre of the table-plate of the staff-head. Now clamp the limb in any position, and turn the telescope to the defining object at the end, A, of the base line, and take the reading on the limb by means of the verniers of the plate. Having recorded this reading, turn the telescope to the object, read again as before, and the difference between these two readings is the angular horizontal distance required. The same for any other two objects.

In making these observations the telescope is, as above explained, to be first roughly directed to the object, while the plate is free, then the plate is clamped, and the accurate bisection of the object by the spider lines is obtained by means of the tangent-screw.

Vertical angles of elevation or depression are taken simply by starting from the horizontal position of the telescope, given to it by its level, then elevating or depressing the telescope to the object, aided by the clamp and tangent screw, P, and reading the semicircle.

I now come to the construction of the theodolite by the workman. Over and above the brass founder, the glass maker, &c., there are three distinct trades involved in the making of such instruments as the theodolite.

1st. The optician (irreverently called the "glass grinder" by the others), who grinds and polishes the glasses of the telescope and the magnifiers.

2nd. The optical turner, whose speciality is the turning of tubular work and the "burnishing in" and counterscrewing of lenses.

3rd. The "framer," or mathematical instrument maker, who does the mounting by which the telescope becomes a mathematical as well as an optical instrument.

I must pass the work of the optician, which belongs to the subject of optical instruments, merely stating the theodolite telescope has, of course, a good achromatic object glass, and is usually fitted with two interchangeable eye-pieces; first a simple, or astronomical, or celestial eye-piece, which shows the object in the inverted position which is given to it at the focus of the object glass; and, second, a terrestrial or erect eye-piece, which is, in fact, a compound microscope, with an object glass that again reverses the position of the object. The celestial eye-piece having fewer glasses obstructs less light, and consequently can have higher power or better definition, and is generally used by those who are not liable to be confused by the visual inversion of the object.

The burnishing in of lenses is a peculiar operation, demanding a certain amount of skill. The lens is placed in a tubular cell, which has a shoulder on one side to catch the lens, and the other side, that by which the lens is introduced, is turned to a thin knife edge which shall stand up all round the lens when it is dropped in. The cell is now chucked in the lathe, and as it turns slowly, while the glass is at first

* Another mode of collimating, effecting the same result, is to adjust each web separately. First make the horizontal web cut some definite point of the object, then turn the telescope half round, and if the web now stands above or below, move it half the distance of the error and try again, until it cuts the same point in both positions of the telescope. The vertical web is then treated in like manner.

held in by the finger of left hand, a burnisher is applied to this edge, which is thus turned over and pressed down till it holds the glass firmly. Large achromatic lenses are usually held in their places by a screwed ring.

The cutting of screws on thin tubes demands the highest exercise of the optical turner's skill. This skill is now largely superseded by devices to be explained in the next lecture.

The collars of the telescope are soldered to the tube and turned by the framer. They are of bell-metal, and bear upon brass. They require to be made accurately equal in diameter, and are therefore carefully guaged or callipered and finished by grinding in the same hole or socket made in two halves, adjustible by screwing them together.

The collimating stop is first marked to indicate the position of the webs. The web used is that of the common garden spider; the spinner of those geometric webs is abundant in summer and autumn. The reason why this spider is selected, rather than the house spider, may easily be seen by anybody who watches the proceedings of each when a fly is caught. The house spider seizes his victim and spins around him a winding sheet of web, before carrying him into the larder. The garden spider binds around his captive a cord of web. It is this cord that is used for collimation.

In the autumn, the mathematical instrument maker goes on his spider hunting expeditions, generally on Sundays. He carries some pill boxes in his pocket, selects well-fed, full-grown specimens, and puts each in a separate box, knowing the savage habits of his six-legged friends; for, if two or more were put together in the same box, only a collection of amputated limbs and mangled bodies would be found on returning home.

The webs are secured for use and storage by making a fork of iron wire, 4 or 5 inches long, and $1\frac{1}{2}$ to 2 inches between the bifurcations. The spider is held in the left hand and allowed to drop, which he readily does when dissatisfied with his quarters, but before falling, he glues an end of cord to the finger, and then lets himself down easily by gradually spinning it out and hanging by it as it lengthens.

The instrument maker catches this cord across his fork, and by turning attaches it to one side, then he goes on turning the fork and advancing it, so that as the spider continues paying out his cable, a series of obliquely crossing threads are wound upon the fork, which, when charged, is carefully laid in a box or drawer for use. The elasticity of the iron wire keeps the webs sufficiently stretched, and they are applied to the stop by simply laying the fork over it in such wise that one of the stretched webs shall fall upon the mark made on its face. When thus in position, a drop of varnish or glue, made by dissolving shellac in alcohol is let fall upon each side; the spirit rapidly evaporates, and the web is fixed.

One of the odd results of this use of spiders is that many workmen become spider fanciers, and keep choice domesticated specimens that learn to spin their webs in convenient places above the work benches, or in the bedrooms of their masters, who lovingly supply them with the fattest of bluebottles. Though I forsook the trade on the expiration of my apprenticeship, I have not yet lost my affection for these animals—I never wilfully kill a spider. A sad story is told of the desolation of the late Mr. Troughton, who on one occasion engaged a new housemaid, and allowed her to commence professional operations without receiving the usual injunctions concerning his pets.

Brass is the material of which theodolites and similar instruments are usually made, though of late gun-metal is coming into use. In brass instruments, the inner vertical axis, the horizontal axis of the telescope, and the telescope collars, are of bell-metal, for two reasons:—1st, its greater hardness; and 2nd, and mainly, because bell-metal works upon brass with less friction than brass upon brass, or bell-metal on bell-metal. As all practical mechanics know, it is a general principle, that unlike bearings work more easily than like upon like. The Y's, the bubble-cock, the stage, the semicircle, the uprights, the plate and limb, the hollow centre of the limb, the clamps, the parallel plates, and the staff-head, are all made from castings.

All these castings, down to the staff-head, must be made of "free" brass, that is brass quite free from iron. The patterns sent to the founder are marked "free," and a higher price paid for such castings, which must be made from new metal—good copper and good zinc—to ensure this freedom. The presence of a single grain of iron or steel filings within range of the needle would, of course, spoil the compass, which stands so nearly in the centre of the instrument. Every casting has to be "tried" by passing every portion of it by the side of a magnetic needle mounted for the purpose.

The brass castings demand another preliminary operation, and receive it from the hand of every conscientious workman, though it is one never demanded by the buyers and users of the instruments; simply because they, like the general public, know nothing about it or its usefulness. This is the hammering. Every part of every casting should be carefully hammered on a flat anvil or stake mounted for the purpose. This adds considerably to the work, inasmuch as it throws the casting out of shape, and demands an allowance to be made for it in the patterns.

Why should they thus be hammered? may be asked. It is simply because cast brass is of granular—in some instances almost spongy—structure, and therefore of low tenacity. When tested by longitudinal strain, acting on bars of one square inch section, it breaks with a pull of 18 to 20 thousand pounds, while brass wire stands 47 to 58 thousand, and sheet, or rolled brass, about 52 thousand. Thorough hammering compresses cast brass very considerably, and quite alters its visible structure, as shown by fracture. It brings it nearly to the condition of sheet brass, and raises its tenacity accordingly. It happens unfortunately, that in many cases the hammer cannot effectively reach the most important part of the casting; this is the case with screws with large heads made of cast brass. The angle close to the head is the point that receives the greatest strain in final screwing up, and this can scarcely be reached by the hammer, hence the common casualty of screw heads twisting off just hereabouts. The tangent screws of a theodolite should always be made of wire with their milled heads fitted on. Most of the smaller screws are turned from wire. Large

screws, like those of the parallel plates, are cast and turned.

As there is no efficient check by which proper hammering of brass can be secured, I strongly recommend the general adoption, for such instruments, of an alloy similar to Baily's metal, but containing more zinc and less tin. They might be made somewhat lighter of such material. They would cost a little more, as the alloy containing tin is not only dearer than brass as raw material, but is harder to work.

When I was in the workshop the slide rest had not yet been generally introduced. The next operation to hammering, then, was planing all such flat surfaces as those of the stage, uprights, semicircle, plate, &c., with a heavy steel-framed hand-plane, using first a toothed or roughing iron, and finishing with a smooth one. These castings are now faced in the lathe with the aid of a slide rest—a very great improvement, both as regards facility and good workmanship. The edges were then "filed up" to proper shape, smoothed, polished, and varnished; but the glories of the polishing stick and rotten-stone buff have now departed, as we shall presently see.

Nobody who has not had actual workshop experience can fairly understand the difficulty of the simple operation of filing flat, *i.e.*, filing across a surface of metal in such a manner that it shall not be rounded, and shall have sharp edges. The narrower the surface the greater the difficulty, and this difficulty increases with the smoothing and polishing of the surface. I have no hesitation in affirming that a boy of average capacity, that had received a fair preliminary school education, would have to work more hours in learning to file, smooth, and polish a flat surface without rounding it, than in acquiring the knowledge requisite for passing the B.A. examination of either Oxford or Cambridge. I speak of hours of work merely; not of intellectual effort. Many cannot acquire the art at all; can only turn out "a cat's back" after seven years' apprenticeship, and working ten hours daily.

The polishing of flat work in the old times was done as follows:—After filing to shape, the work was "smoothed up," that is, filed over with a "bastard pottance" file, then a "pottance" file, then a "smooth" file. After this, if to be left "grey" or grained, it was rubbed with emery paper tightly stretched over a smooth file; first with rough paper, then with new smooth paper, and finally with well worn and brassy-looking smooth paper slightly oiled. Great skill was demanded to do this without rounding the edges. The result was a semi-polished surface, showing fine but regular markings of the smooth paper.

Bright polishing of such surfaces was performed by smoothing and partially papering as above, then rubbing the surface with a mahogany stick shaped like a file, but thicker, and anointed with ground pumice and oil. When all the paper marks were taken out by this, the pumice was wiped off, and the pumice marks rubbed out by using a similarly shaped stick made of lime-tree wood, and anointed with powdered blue-stone (a sort of homogenous slate) and oil. This was followed by rotten-stone and oil on the same stick, and finally by a few deftly applied strokes of a stick upon which was stretched a piece of West of England broadcloth, moistened with rotten-stone and oil. This, if well done, produced a mirror-like or "black" polish. The oily material in either case was removed by rubbing the work with whitening, by means of a rag and smooth plate-brush.

When thus cleaned and dusted the work was ready for varnishing, the varnish being not the common dark lacquer of vulgar door knobs and such-like, but a specially prepared pale "mathematical varnish," made by a man living near Wardour-street, by skilfully dissolving light shellac in alcohol. This was brushed lightly over the work when just at the temperature of boiling alcohol. If hotter it became dark, like vulgar lacquer; if not hot enough, it made a paint-like smeary surface. In either case it was removed, and the work repolished.

I went last Saturday to the old shop where I was apprenticed, Street's, No. 39, Commercial-road, Lambeth, and there borrowed the theodolite I have shown you, and all these castings for every part of the instrument, the spider-web fork, collimating stop, &c., all nearly as they were in 1841 when I left, and though I saw my old bench, and the other benches, vices, and lathes as of old, I could not borrow a polishing stick, no such things being now in use there. They still linger among microscope makers, and in a few other departments of the trade.

Why is this? The end of the polishing stick began before I left, at about 1838 or 1839, when a large order came to London for a number of Everest's theodolites (to be described in next lecture) for the great Ordnance Survey of India, all to be bronzed instead of polished, on account of the glare of polished brass in India. These were only smoothed and roughly papered, then painted over while hot with a solution of platinum, which precipitated platinum black adhering to their surface. This was afterwards brushed over with plumbago, like the blackleading of a vulgar stove, and then varnished with vulgar gasfitter's lacquer. Great, indeed, was the disgust of all the old and orthodox workmen thereat; but the Vandals overspread the land, the polishing stick is no more, and levels, sextants, transits, &c., are now bronzed, and some are even painted with lamp black suspended in a medium of shellac varnish.

This is not all. In some great shops even filing up is abolished. A steel template is laid upon the flat side of the work, and a revolving cutter, worked by a steam-engine, travels along the edge, guided by a smooth bearing, and thus literally licks the thing into shape at once, and leaves it smooth enough for the bronze or lamp-black paint that follows directly.

But however the mechanical work may be modernised and economised there still remains the old necessity for scrupulous accuracy in finishing the working parts. Thus the axes must be turned upon dead centres, *i.e.*, instead of chucking one end, or otherwise allowing them to revolve with the mandril of the lathe. The inner bell-metal vertical axis must be finished by making it turn upon its own centre, which rests upon non-moving centres of the lathe, and the outer axis, or centre of the limb, must be finished upon this, so that the two axes upon which the whole instrument turns horizontally shall be a true mathematical line, and not a cone, as it might be

if the centre were turned by means of an ordinary revolving lathe mandril, the centre of which might have a little orbit of its own, round which it would carry one end of the theodolite axis, while the other turned upon the dead centre of the poppit head.

Then, again, the chamfered edge of the limb B must be finished in like manner, by touching it with a fine point tool, while upon its own centres or axis, and these are turning upon the dead centres before named.

The same precautions are demanded for the horizontal axis and the semicircle it carries. The uprights must be made exactly of equal height from their feet to the bearing of the horizontal axis, otherwise the telescope will not make a vertical sweep when the limb and plate are adjusted to horizontality. To effect this, they are both pinned and filed together, and reversed again and again, and both are drilled together and reversed; and after that their feet are filed again while clamped together with the finished axis in its place, and, after the filing, ground upon a flat plate. After all this they are optically tested, when the instrument is finished by levelling the plate as above described, then cutting an object with the vertical web and reversing the horizontal axis. If the web and object still coincide, the horizontal axis is parallel to the plates, or at right angles to the vertical axis, and when the plate is levelled the telescope sweeps vertically. Not only must the uprights themselves be equal, but the bearing ends of the horizontal axis must also be of equal diameter.

The Y's and the stage have to be similarly adjusted, in order that the telescope may rest at right angles with the perpendicular line on the semicirle to which the zero is marked. If not so, the deviation must be recorded as index error, and added to or subtracted from the observation reading.

The vertical axes or centres have to be carefully ground with pumice until they just fall upon their bearing shoulders without either shaking or binding. They are conical, and cut away at the middle, only bearing at each end on about half their length.

The subject of dividing and vernier reading must be postponed to the next lecture, and I must now conclude this lecture, already too long, by describing the use of the double reading on the limb of the five-inch theodolite, and the multiple readings by many verniers on this fine instrument, a 14-inch theodolite that has been used as a fixed station theodolite in the great Indian survey, and is now come home on sick leave, being out of repair. As the best of dividing is subject to error it requires checking. This is done by the multiple readings; each vernier starts from a different part of the limb, and terminates accordingly. Each is read independently, and the mean of all the readings is adopted.

"Repeating" is a similar operation, and even more effectual. It was invented by Tobias Mayer, of Gottingen, in 1752. It is not possible with every instrument, but may be done with the horizontal readings of the ordinary theodolite, thus—Take a reading from object A to object B in the usual way, starting, say, from O. Let it be 30° 10′. Now, leaving the plate clamped to the limb, loosen the clamp H, and turn the whole instrument back to A. Then clamp H and release the plate, and turn again to B, in the same direction as before. Thus the reading will be repeated, beginning at 30° 10′ instead of O. Suppose the result now be 60° 25′. Then repeat again, as before, starting, of course, this time from 60° 25′. Suppose the third reading be 90° 40′, dividing this by the number of readings we get the mean of 30° 13′ 20″. This may go on round the whole circle, and round again with continual division of error thereby. It thus affords fractions of the finest possible direct readings of the instrument.

Special instruments, with horizontal or vertical limbs, mounted expressly for repeating, are called "repeating circles." Borda's Vertical Repeating Circle, used by the French for measuring the meridian from Dunquerque to Barcelona, upon which the metre was based, is a celebrated instrument of this class.

The illustrations for this lecture were a 5-inch theodolite on stand; and a complete set of theodolite castings, spider-web fork, and collimator stop, lent by Mr. Street, of Commercial-road, Lambeth. A 14-inch theodolite, used in the Great Indian Ordnance Survey, was lent by Mr. Cushing from the East India Stores.

MISCELLANEOUS.

GAS AND ELECTRICITY.

An important experiment in gas lighting is now being carried out by the Phœnix Gas Company in the Waterloo-road. For the past ten days a section of this road, extending from the south end of Waterloo-bridge to the South-Western Railway Company's Terminus, a distance of 500 yards, has been lit by gas in a new and greatly extended manner. Hitherto, this portion of the Waterloo-road has been lighted by 22 ordinary lamps of the common form, these have now vanished, and in their places there are 48 new lights enclosed within improved lanterns, and supported upon shorter and more tasteful columns. Further, the old burners each gave, or were supposed to give, a light equal to 12 sperm candles, the new ones are now giving a light of 15 candles. Besides this, two lamps on each side of the road at the bridge end are fitted with Mr. W. Sugg's new concentric ring argand burners, each giving a light equal to 50 candles. At that part of the road where it is intersected by the York-road and Stamford-street there are two "sanctuaries" or "refuges," and here, undoubtedly, the gauntlet is thrown down boldly to the electric light. In the centre of each "refuge" there stands an iron column carrying a very elegant form of lantern; each lantern is fitted with a burner having four rings, and each burner gives a light equal to 200 candles; also at each corner of the York-road and Stamford-street there stand burners of 50 candle power. According to the old plan of lighting, this piece of Waterloo-road cost $5\frac{1}{4}$d. per hour, all expenses included. According to the new arrangement the cost is raised to 17d. The cost of lighting such a thoroughfare with the electric light, according to the most reliable figures obtainable, would be about 1s. per hour per lamp. Taking 50 yards as the distance between each lamp (this is about the distance between the lamps on the Embankment), then 20 of such lamps

would be required to light such a portion of road as that referred to; this would give 20s. per hour for electricity, as against 17d. for gas. The above experiments have been carried out under the personal superintendence of Mr. Corbet Woodall, the engineer of the Phœnix Gas Company, the burner and lantern having been devised and supplied by Mr. W. Sugg, of Westminster.

AUSTRALIAN EXHIBITIONS, &c.

Mr. Samuel H. Roberts, Hon. Corresponding Member of the Society, writes as follows:—Preparations are being actively carried on for no less than three exhibitions. The International Exhibition at Sandhurst (one of our largest mining centres) to be held next year; a Juvenile Industrial Exhibition, also to be held next year in Melbourne; and the great International Exhibition of Melbourne to be opened in 1880. Tenders for the building are to be opened next week. A splendid design has been prepared by the architects, Messrs. Reid and Barnes. The estimated cost of the building is between £60,000 and £70,000. The commission to carry out the undertaking consists of about fifty members, and they have just appointed J. C. Levey, C.M.G., as the secretary. I send circulars and programmes of the Sandhurst and the Juvenile Exhibitions. Those of the International Exhibition are not yet out, but are expected before the mails leave to-morrow. If they are issued I will send you them also.

There is also to be an exhibition in Sydney next year, and so many applications for space have been received, that the enterprise has assumed a magnitude not at first expected, and above the present means of the committee; it is however probable that the New South Wales Parliament will come to their aid with an adequate grant.

The question of Chinese immigration is agitating the minds of the people of Sydney and the northern portions of Australia. Public meetings have been held, and resolutions adopted, calling upon the Government to take measures to restrict these in coming to the colony. One very serious result of the antipathy to the Mongol race is a strike of the seamen engaged by the Australian Steam Navigation Company, owing to the Chinamen being employed on some of their steamers, and the probability of the number being shortly increased; meanwhile the ships of the company are laid up for want of crews. The commerce of the port is, for the time, much injured by the dispute.

Large additions are in progress at the Melbourne University through the princely generosity of Sir Samuel Wilson, who has presented £35,000 to the institution. This good example has just been followed by Mr. Ormond, who has promised £10,000 towards building a Presbyterian College in connection with the University, on condition that an equal sum be subscribed within twelve months. As already £6,000 has been sent to the committee, there is no doubt as to the condition being fulfilled.

CORRESPONDENCE.

AUTOMATIC COUPLINGS.

Owing doubtless to my desire to provide my audience with the latest information in my paper of the 15th, the totals under column A in the tables printed in the Society's *Journal*, page 107, were given incorrectly. There was an omission of $2\frac{3}{4}$ millions, which should appear as the goods mileage of the Lancashire and Yorkshire Railway for 1877-8, the numbers $3\frac{1}{4}$, $1\frac{3}{4}$, and 2 should be one line lower respectively, and the total should stand at 44,250,000 instead of 90 millions. May I ask you to notice this in your next issue?

T. A. BROCKELBANK.

OBITUARY.

Mr. Thomas Sopwith, F.R.S.—Mr. Thomas Sopwith, M.A., F.R.S., F.G.S., died at Westminster on Thursday, the 16th inst. He was born in 1803, at Newcastle-on-Tyne. He was for nearly 50 years extensively engaged as a civil engineer in mining, railway, and other works, both in this country and on the Continent, and was the author of several works on architecture, isometrical drawing, and mining. In 1838 he was appointed Commissioner for the Crown under the Dean Forest Mining Act, and in the same year a communication made by him to the British Association led to the establishment of the Mining Record-office. He became a member of the Society as long ago as 1843. In 1858 he came upon the Council, from which he retired in 1864.

GENERAL NOTES.

Italian Trade Mark Statistics.—The following figures give information concerning the registration of trade-marks, and the delivery of certificates for them in Italy, between the years 1869 and 1878 (up to July 1st in the latter year):—In 1869 there were 21 certificates delivered to natives, 2 to foreigners, making a total of 23; in 1870 5 were delivered to natives, 16 to foreigners, making a total of 21; in 1871, 5 were delivered to natives, 12 to foreigners, making a total of 17; in 1872, 12 were delivered to natives, 20 to foreigners, making a total of 32; in 1873, 12 were delivered to natives, 3 to foreigners, making a total of 15; in 1874, 15 were delivered to natives, 87 to foreigners, making a total of 102; in 1875, 20 were delivered to natives, 23 to foreigners, making a total of 43; in 1876, 18 were delivered to natives, 114 to foreigners, making a total of 132; in 1877, 20 were delivered to natives, 66 to foreigners, making a total of 86; and in 1878, 8 were delivered to natives, and 28 to foreigners making a total of 36. The totals for $9\frac{1}{2}$ years were 136 certificates delivered to natives, 371 to foreigners. The following was the revenue derived from this source in the $9\frac{1}{2}$ years:—From the special tax, 18 960 francs, from the stamps, 4,716; a total of 23,666 francs.—*Trade Marks.*

Reporting Machine.—Amongst apparatus which may be called literary aids—writing, calculating, and other machines—seen at the Paris Exhibition, was one which attracted much attention, and which has not yet been introduced into this country. It is known as *La Machine Sténographique Michela,* the name of its inventor. The claims made respecting it are very broad. In the first place, it is declared that after a fortnight's practice, any person of ordinary ability can take down in shorthand characters any speech however rapidly delivered. It is a small instrument, piano-like in form, with twenty-two keys, white and black, and the stenographic characters are small and impressed on slips of paper. Signor Michela claims to have classified all the sounds which the human organs of speech are capable of producing, and to have so constructed his machine that it shall report with unerring fidelity whatever is said, German, French, Italian, and Spanish, and, it may be taken for granted, that English is also included, as the exhibitors announce their intention of introducing the machine into this country. The inventor even believes that his machine will do much towards the realisation of that philosophic dream, an universal language. To what extent the hopes of the inventor may be realised, of course, remains to be seen, but the machine is certainly highly ingenious, and seems to work satisfactorily.

The estimated aggregate value of the various minerals produced in New South Wales to December 31, last year, is set down at £46,439 130. The aggregate value of the minerals raised during 1877 amounted to £2,233,161 as compared with £2,183,096 in 1876, showing an increase for 1877 of £50,065.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at Eight o'clock:—

January 29.—"The Distribution of Disease popularly considered." By Alfred Haviland, Esq., M.R.C.S.E.

February 5.—"The Best Methods for Improving the Condition of the Blind." By Dr. T. R. Armitage.

February 12.—"The Application of the Bessemer Process to the Reduction of Metallic Sulphides." By John Hollway, Esq.

February 19.—"Turkey and its Resources." By J. L. Haddan, Esq. Lieut.-Gen. Sir A. B. Kemball, K.C.S.I., C.B., R.A., will preside.

February 26.—"Indian Pottery at the Paris Exhibition." By George Birdwood, Esq., M.D., C.S.I.

March 5.—"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By Joseph J. Pope, Esq., M.R.C.S., L.S.A.

March 12.—"The Compensation of Time-keepers." By Edward Rigg, Esq., M.A.

March 19.—"Economical Gardens for Londoners." By W. Mattieu Williams, Esq., F.R.A.S., F.C.S.

March 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor Barff, M.A.

CHEMICAL SECTION.

Thursday Evenings, at Eight o'clock.

January 30.—"Gas Illumination." By Dr. Wm. Wallace, F.R.S.E. C. Woodall, Esq., M.I.C.E., will preside.

February 13.—"Noxious Vapours, with Special Reference to the Report of the Late Commission."

March 13.—"On the Injurious Effects of the Air of Large Towns on Animal and Vegetable Life, and on Methods Proposed for Securing Salubrious Air." By W. Thomson, Esq., F.R.S.E.

INDIAN SECTION.

Friday Evenings, at Eight o'clock.

January 31.—"Quest and Early European Settlement of India." By George Birdwood, Esq., M.D., C.S.I. Andrew Cassels, Esq., Member of the India Council, will preside.

AFRICAN SECTION.

Tuesday Evenings, at Eight o'clock.

February 4.—The Opening of the District to the North of Lake Nyassa, with Notes of a Recent Expedition through that Country." By H. B. Cotterell, Esq.

March 18.—"Some Remarks upon an Old Map of Africa contained in Janson's Atlas, published at Paris in 1612." Communicated and exhibited by R. Ward, Esq.

April 1.—"The Contact of Civilisation and Barbarism in Africa, past and present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock. First Course, on "Mathematical Instruments." Six Lectures, by Mr. W. Mattieu Williams.

Lecture VI.—January 27, 1879.

Instruments for Recording or Representing Results of Mathematical Processes.—Plotting and Drawing Instruments.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Household Sanitary Arrangements." It will consist of Six Lectures, to be given on the following dates:—

February 17, 24, March 3, 10, 17, 24.

The Third Course will be by Mr. W. H. Preece, on "Recent Advances on Telegraphy." It will consist of Five Lectures, to be given on the following dates:—

April 21, 28, May 5, 12, 19.

Members can admit TWO friends to each of the Ordinary and Sectional Meetings, and ONE friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures. Mr. W. Mattieu Williams, "Mathematical Instruments." (Lecture VI.)
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. 1. Major-General Sir Henry C. Rawlinson, "The Road to Merv." 2. "The recent Overflow of the Lower Oxus."
British Architects, 9, Conduit-street, W., 8 p.m. 1. Discussion on Mr. Verity's paper, "The Modern Restaurant." 2. Mr. Francis C. Penrose, "Notes on St. Paul's Cathedral."
Institute of Actuaries, The Quadrangle, King's College, W.C., 7 p.m. Mr. G. S. Crisford, "The Messenger Prize Essay on Surrender Values."
Medical, 11, Chandos-street, W., 8.30 p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Dr. B. W. Richardson, "Health and Recreation." (Lecture II.)

Tues. ...Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture III.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. 1. Discussion, "The Railway Systems of South Australia." And, time permitting—2. Mr. Edward Dobson, "The Geelong Water Supply." 3. Mr. Joseph Brady, "The Sandhurst Water Supply."
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. Annual Meeting.
Metropolitan Scientific Association, 160A, Aldersgate-street, E.C., 7 p.m.

Wed. ...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. Alfred Haviland, "The Distribution of Disease Popularly Considered."

Thur....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Chemical Section.) Dr. William Wallace, "Gas Illumination."
Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 7 p.m. Sir Edmund Beckett, "The Meaning and Origin of the Laws of Nature."
Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. H. Gordon, "Electric Induction." (Lecture III.)
Philosophical Club, Willis's-rooms, St. James's, S.W., 6½ p.m.

Fri.......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Dr. George Birdwood, "Quest and Early European Settlement of India."
Royal United Service Institution, Whitehall-yard, 3 p.m. Mr. W. H. Preece, "The Electric Light."
Royal Institution, Albemarle-street, W., 8 p.m., Weekly Meeting. 9 p.m. Mr. H. Heathcote Statham, "The Logic of Architectural Design."

Sat.......Working Men's Club and Institute Union (at the House of the Society of Arts), 4 p.m. The Very Rev. the Dean of Westminster, "Reminiscences of the United States in Westminster Abbey."
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Seeley, "Reptilian Life." (Lecture III.)

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,367. Vol. XXVII.

FRIDAY, JANUARY 31, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

SAVING LIFE AT SEA.

Acting on the recommendation of the Committee appointed for the purpose, the Council have awarded the Gold Medal of the Society, offered "for the best means of saving life at sea, when a vessel has to be abandoned suddenly," to Messrs. J. and A. W. Birt, for the collection of buoyant articles sent in by them. The following also receive honourable mention:—

1. Messrs. Birt, waterproof sheet.
2. Mr. Bryson, deer-hair.
3. Mr. A. Hely, waterproof bags.
4. Admiral MacDonald, canvas boats.
5. Mr. H. Newton, cork belts.
6. South Western Railway Company, metal cylinders.
7. Mr. P. P. De La Sala, canvas boats.
8. Mr. J. W. Watts, sleeping berths.
9. Mr. A. Wood, moose-hair.

The full report of the Committee will be published immediately, and a copy of it will be sent to each of the competitors.

ADDITIONAL LECTURES.

The first of a short Course of Two Lectures, by Dr. B. W. Richardson, M.A., LL.D., F.R.S., on "Some Further Researches in Putrefactive Changes," in continuation and completion of his course of Cantor Lectures last year, will be given on Monday next, the 3rd February, at 8 o'clock.

EIGHTH ORDINARY MEETING.

Wednesday, January 29th, 1879; Edwin Chadwick, C.B., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Armstrong, Mrs. Emily, Dolgelly, North Wales.
Neuhaus, Capt. Mathias, 61, Charlotte-street, Portland-place, W.
Tayler, Frank, 156, Leadenhall-street, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Barron, William Adamson, Althorpe-house, Queen's-road, Richmond-hill, Surrey.
Begbie, Robert S., Stafford-lodge, St. Mary's-terrace, Paddington, W.
Benjamin, Eugene, 169, New Bond-street, W.
Cook, Edward C., 208, Oxford-street, W.
Halliday, William, 4, Northampton-terrace, Harrow-on-the-hill.
Lewis, John, 7, Harley-place, Regent's-park, N.W.
Logan, William George, 9, Adelphi-terrace, W.C.
Neill, John, M.A., Greenock.
Nolloth, Admiral Matthew Stainton, A 12, Albany, W.
Parker, Walter M., Alton, Hants.
Read, Richard John Gifford, 15, Flora-villas, Albion-gardens, Hammersmith, W.
Saunders, Captain A. J., R.A., Gatestone, Central-hill, Upper Norwood, S.E.
Spalding, Frederick George, Lennox-house, Manor-way, Blackheath, S.E.
Verno, Amadie, La Société Indienne de l'Electricité, 29, Rue Taitbout, Paris.
Weir, William, 38, South Audley-street, W.
White, Thomas John, Amana-lodge, 140, Tulse-hill, S.W.

The paper read was—

THE DISTRIBUTION OF DISEASE POPULARLY CONSIDERED.

By Alfred Haviland, M.R.C.S.E.

It will be necessary, in the first place, to give a brief definition of what is meant by distribution of disease. From the time of Hippocrates—and, perchance, long before—it has been well known that those inhabiting certain localities are liable to be affected, more or less, by diseases peculiar to them. For instance, the intermittent fevers incidental to man in lands at the *embouchures* of rivers or elsewhere—in fact, wherever a marsh has been formed, whether at a high or low level—are good illustrations of what may be called endemic diseases. These are what may be termed stationary diseases, affecting only those who come within the range of the local poison.

Other diseases there are, like cholera, which had its origin in that gigantic swamp, the delta of the Ganges, and is capable of being distributed broadcast over the world in a manner that has, as yet, defied every attempt at explanation, although it must be confessed that, at each visitation of this modern plague, some fresh fact in its natural history is discovered, and these facts have enabled sanitarians to devise means, not only of limiting, but, to a certain extent, of preventing its ravages. I have only to recall your attention to that great fact of this dreadful disease being, like typhoid and other fevers, capable of dissemination by means of drinking water. This, once discovered, led eventually to grand results in our endeavours to prevent a vast number of other diseases. This fact, however, was only discovered by studying carefully the distribution of the plague, and investigating, one by one, all the possible factors concerned in it.

By distribution of disease we mean the mode in which any disease affects certain localities, and the study of this branch of knowledge involves, first, accurate statistical records of deaths, and cases of the disease to be investigated, and as sound a knowledge of the physical and geological characters of the countries in which it exists, the social characteristics of the people, their employment, and every other factor that may help to account for the phenomena of the disease investigated. We have to note not only all the factors of the localities in which the disease abounds and thrives, but, as we shall see in the sequel, what are the characteristics of the places where it does not thrive, and after we have obtained all that is to be learnt from the mortality returns of this country, we place these figures on a chart, and then, either by colours or otherwise, indicate the different degrees of mortality which exist in different places. When this is done, we really have pourtrayed, as well as we can do, the distribution of the disease under investigation. Having thus briefly defined what is meant by disease distribution, I will give an account of the mode that I have adopted to illustrate this subject. The maps before you are coloured so as to give at a glance the death-rate in England and Wales of several diseases. The statistics on which the whole are based extended over two years. Before entering upon the method I have adopted, and which I wish to see popularised, I ought to remark that I have hitherto confined myself to the diseases of our own country. In Dr. Keith Johnston's "Atlas" you will find an admirable map of the world, coloured so as to show what he calls the disease realms, and he has indicated by red letters the special diseases which affect certain localities; for instance, in North America he notes "Small-pox was destructive among the Indian tribes;" under latitude 60° he notes "the northern limit of goitre." On the coast of North and South America, we see "No endemic disease" extending from 40° N. lat. to 50° S. lat.; on the other hand, along the east coast of both North and South America to the West Coast of Africa, we see the map thickly strewed with the words, "remittent fevers," "yellow fevers," "dysentery," "remittent fevers endemic and very severe." It is very evident that Dr. Johnston, with the materials at his command, could but give an outline of the geographical distribution of disease and health. Still, he was the great pioneer of this work, and what he did has been of immense value to the medical geographer and physician. I, perhaps, may be allowed to say that when I showed the mode I proposed, and have since carried out, of pourtraying disease distribution, to this eminent geographer, he acknowledged that it was the only true method of carrying out my object.

Several years ago, there was an idea prevalent that the constant travelling by railway caused an increased amount of heart disease amongst those who lived at a distance from their offices, and travelled to and fro daily. This idea was strengthened by the fact of several sudden deaths from heart disease having occurred on certain lines of railway leading out of London. The matter was, I believe, thoroughly investigated so far as the individual deaths were concerned, but it appeared to me that the basis of investigation was too confined, and I therefore undertook to examine how heart disease and dropsy were distributed throughout England and Wales. The results of that investigation are now before you, not only in the form of the original large map, but of the printed map which is attached to my work on "The Geographical Distribution of Heart Disease, Cancer, and Phthisis." Directly I obtained the results which I have now formulated, I conceived the idea of popularising them, so that all could understand and take an interest in them; for I felt then, and more than ever do I feel now, that unless the grand facts of disease distribution were presented in such a form as to be easily understood at a glance, sanitarians might fill books after books with statistical tables, and the public be none the wiser. Since I have been a medical officer of health, I have almost daily evidence of the correctness of this idea, and it was with the view of popularising this subject that I commenced and carried out a series of coloured maps, pourtraying the distribution of disease in England and Wales.

An appeal to the eye, it is well known, goes more direct to the understanding than it does through the ear, and this fact has been elegantly rendered by Horace—

> "Segnius irritant animos demissa per aurem,
> Quam quæ sunt oculis subjecta fidelibus."
> Hor. Ars. Poet., v. 180-1.

We all know how vividly and lastingly a historical fact is impressed upon the public mind and memory by the genius of painting; an effect which even the pens of Allison or of Gibbon, with all their vast wealth of word-painting, would fail to produce. We have only to remember the effort on the public mind of such pictures as Haydon's "Judgment of Solomon," and his cartoon of "The Fall of Man," exhibited in Westminster-hall, before which last men reverently took off their hats as they viewed it. Again, the death of the lamented Ward recalls his well-known and shocking pictures, "The Last Sleep of Argyll," "The Reading of the Death Warrant to Marie Antoinette," and others of equal merit; it also recalls to our memories how, when they were exhibited, the public eye was rivetted on them, and indelible impressions made upon the public memory of the historical fact brought before them by the cunning hand of him who is now no more.

True it is that the pen of the historian was necessary for the artist, for without it such truthful representations could not have been depicted. As with the painter, so with the maker of disease charts—without the elaborate figures of the statisticians, and without patient groupings of these figures, such simple charts as are now before you could never have been painted. The artist uses form and colour to represent the words of the historian, and I have ventured to use form and colour to represent the figures of the Registrar-General.

The mode I have adopted rests upon the dividing out of England and Wales, for the purposes of registering the births, deaths, and marriages, into registration divisions, counties, districts, and sub-districts.

The series of maps showing the geographical distribution of scarlet fever for the years 1851-70 will best show the mode I have invariably adopted

in an attempt to popularise disease distribution. In the first place, I estimate the annual average death-rate for any given number of years, and having ascertained the general average, I make a scale of colours consisting of six degrees—three above the average and three below it—three above being coloured blue in varying degrees of intensity, and three below red in different shades, the degree representing the highest mortality being the darkest blue, and that indicating the lowest degree the darkest red. I use the same degrees for all the maps, and in order to remember which are the high mortality districts, and which the low, I must tell you that I selected these colours red and blue because they represent the colours of the two kinds of blood which circulate in our bodies, both the arterical and venous. Now most people know that the dark blue blood which flows in our veins has done its work, and so far as nutrition is concerned, is effete, and incapable of maintaining the health. It may be said to represent unhealth or disease, requiring as it does to be removed in the lump with a fresh supply of oxygen. Its colour, therefore, has been selected to represent the high mortality groups. On the other hand, arterial blood is known to be of a bright florid red as it issues from the lungs, full of renewed life and vigour, and intended for the nutrition of the body; it is health-giving and full of life. It is, therefore, well adapted for those districts where the mortality from any cause is below the average, or at *nil*. In some of the maps, where there have been no deaths for ten years from any cause, I have left the district blank, surrounded by a red line; and in some exceptional cases, where I have been obliged to increase the number of degrees, I have used black to represent the highest degree of mortality. This I was obliged to do in the map on the geographical distribution of diphtheria, which I am now preparing, and which you will see on the wall. I have had no reason to alter the plan I adopted at first, and I find it most convenient in illustrating the disease distribution of my own sanitary area, which extends over eleven hundred square miles.

I will now briefly carry you through the process by which I arrive at the results that I have continued from time to time to publish, and I will take the distribution of scarlet fever, as I happen to have all the three large maps at hand. As a rule, I work out the divisions and counties' death-rates on small maps, which would be quite unsuited for my present purpose, and I indeed fear that the maps I now exhibit will be scarcely large enough to be seen everywhere in this hall. England and Wales are divided into eleven great divisions, which are made up of counties. These counties are then sub-divided into districts, and the districts again into sub-districts. The first three divisions are here represented. After estimating the average annual rate of mortality in the divisions from any cause, I colour the divisions according to their degrees of mortality; for instance, as in the case of scarlet fever, the scale will be as follows for the twenty years 1851-1870:—First, or highest degree of mortality, the average annual rate of mortality would be 14 and upwards; the second, 12-13; the third, 10-11; the fourth, 8-9; the fifth, 6-7; and the sixth, or lowest, 4-5, to every 10,000 persons living, the average being 9·1 for the above period. Having coloured the divisions, my next process is to discover which of the counties in each dominate the mortality, or *vice versa*.

I will first draw your attention to the map representing the distribution of scarlet fever in the eleven great divisions. Beginning with the divisions having the highest mortality, we find that the north-western division (VIII.) had the highest mortality, and that the northern division (X.) reached next, the two forming a group of high mortality. We then come to the VIth, the IXth, and the XIth divisions, all coloured so as to indicate the fourth degree of mortality, or the degree just below the average. This group ranges from Yorkshire through the centre of England, and includes the whole of Wales. To the south-east of this last group we see the remaining part of England coloured so as to indicate the fifth degree of mortality, with the exception of No. I. division—which includes the London division—seen to be coloured light blue, showing that its mortality is of the third degree, or equal to an annual average death-rate of from 10 to 11 to every 10,000 persons living. Now, a glance at the colouring of these divisions will enable us to guess where we shall find the counties dominating the mortality from this terrible cause of death. The disease seems to have a firm hold on the north-western and northern counties, and these divisions have extended their influence to the intermediate group, consisting of the IXth, VIth, and XIth divisions, for we find that the average mortality only belongs to the fourth degree, whereas the next large group of divisions, most remote from these north-western high mortality divisions, has a mortality only equalling the fifth degree. Let us now turn to the counties and see the part that they have played in dominating the divisional death-rate from scarlet fever during the 20 years taken. In the first place, the VIIIth division, which has the highest mortality, and is composed of Cheshire and Lancashire, had its death-rate dominated by the county of Lancaster, and the northern division (IX.) had in a similar manner its scale of mortality raised by the county of Durham, in spite of the counteracting influence of the comparatively healthy county of Cumberland. The colouring shows at a glance how the mortality has been distributed among the counties, those having the highest mortality being Durham and Lancashire, and those having the least, Suffolk, Huntingdon, and Hereford—the highest mortality counties being the manufacturing and mining counties, and the lowest essentially agricultural. If we now turn to the map of the districts, we shall in a moment discover what districts have contributed to bring about the above results. In the county of Durham we find a group of deep blue districts, all huddled together, of the highest degree of mortality. In the county of Lancaster we see a group of seven or eight degrees of the highest mortality; in that of Stafford we have one of the second degree of mortality, and in that of South Wales one of the highest mortality; and it is noteworthy that throughout the remainder of England and Wales not a single district is returned so as to indicate an average death-rate from this cause usual to the first degree. It is also noteworthy that these darkest-blue

counties are surrounded by districts having the second and third degrees of mortality, and that it is exceptional to find the lowest mortality districts in close proximity to them, unless the physical geography of the country happens to render intercommunication difficult. In these dark-blue centres of infection, scarlet fever seems ever to be stored, ready at a moment's notice to be carried far and near; the names, therefore, of these districts, and the towns and villages which they contain, should ever be remembered by those investigating outbreaks of scarlet fever, and I feel convinced that a map such as I now show would be of essential service, not only to medical officers of health, but to others who wish to avoid epidemic centres. This scarlet fever baffles all, for it is apt to appear amongst us in apparently the most unaccountable manner. But, I believe, most of the epidemics which break out in places that are not, as a rule, the seats of this disease, can be traced to the great centres indicated here. At all events, it is but natural to expect that, with the enormous amount of travelling that takes place at the present day, these fever stores should yield an abundant supply of poison, not only to their neighbouring districts, but to the most remote, in fact, every day's experience tells us that such is the case. It would not do now to enter more fully than I have already done into the geographical distribution of scarlet fever in England and Wales. What I have already said and shown you is sufficient to explain the mode I have adopted for geographising disease—with the view of popularising the study, and of rendering it easily understood by all. I may remark, before leaving the subject of scarlet fever, that the map before you represents 374,299 deaths during the twenty years 1851-70. Next, in 1851-60, there was 166,432 deaths, and in the decennial period, 1861-70, 207,867, and it is disheartening to know the fact that the average annual rate of mortality increased during the last decennial. Thus, during 1851-50, it was 8·8, and during 1861-70 9·7 to every 10,000 living. It is to be hoped that the Registrar-General will be able to give us in due course a better account of the current decennium, but I fear we must not be sanguine on this score, whilst by feasts, fairs, and other gatherings, human disease is allowed to be spread without let or hindrance. What is wanted is that the health and lives of human beings should be protected by the Legislature, and at least placed on a level with those of pigs and cattle.

Having given you an idea of how disease may be geographised, and its distribution shown so as to impress the mind with facts, which a whole army of figures would fail to do, I will now draw your attention to some of the other maps, and show you some of the results of the investigation with which I have been for a considerable time engaged.

As I have already told you, the map on the distribution of heart disease was the first I constructed, and certainly the results were most unexpected. By this map I showed that the physical conformation of the country determined in the first instance the places where rheumatism would be found prevalent or otherwise, and whilst making this investigation, during a tour among the districts having the highest mortality from heart disease, I found that in all those localities rheumatism was not only the prevalent disease, but a disease that would perplex the medical man at all times during the convalescence of his patients from other diseases. After having made the large map before you, I carefully studied all the localities where heart disease prevailed and where it was scarce, and I very soon came to the following conclusions:—

1. That, wherever the prevailing winds had, in consequence of the axes of the valley systems being favourable to them, full power of flushing, there was to be found the least amount of rheumatism and heart disease.

2. That, on the contrary, wherever the valley system was of such a form as to preclude their flushing, and obstructed the prevailing winds, forcing them, as it were, to blow over instead of through them, there was to be found the greatest amount of heart disease and rheumatism.

3. That wherever the axes of the rivers of a district corresponded with the general direction of the prevailing winds and the tidal wave, there also were to be found the least amount of these two diseases; and, lastly,

4. That where the axes of the rivers were at right angles to the prevailing winds and the tidal wave, there was to be found excessive mortality.

I cannot conclude without expressing my opinion that the great majority of heart disease cases in our country have their origin in rheumatism, and that this disease in many parts of England is endemic.

Heart disease, if we use the term generally, has almost every variety of cause imaginable. But the heart disease which kills in such large proportions, is of insidious growth, often unsuspected in youth, and frequently allowed to go unheeded until it has taken too firm a root to be removed. I believe that it does not require a regular attack of rheumatic fever in order to set up disease in the heart, as experience extending over more than a quarter of century in hospital and private practice, leads me to believe that in certain localities rheumatic disease begins to show itself very early in life, and that from the neglect of the first symptoms much mischief accrues. In agricultural districts we see too frequently the crippling effects of chronic rheumatism.

I think that the physical characters of the country, as indicated above, point to some *materies morbi* resident in certain localities, perhaps in all; the only difference being that one district is frequently purged by the beneficial influence of sea winds, whereas another is so sheltered as to admit of an accumulation. This accumulated air-sewage may have either an animal or a vegetable origin, or both. It is impossible to say. All we know is that it is coincident with excess of rheumatism and excess of heart disease. What we see obtain in the deep, unventilated valley districts of Devon, Dorset, Hants, and Hereford, we find in towns where a free flushing of the air-sewage is precluded, either by the natural position of the town itself, or, if well situated for air flushing, by the bad arrangements of the streets, which may be so built as to intercept what would thoroughly ventilate them, and, either chemically or physically, rid them of the disease poison.

In the agricultural districts, I have no doubt that low wages and low living combine to render

the body unfit to contend against the external influences which are to be found in certain districts. An ill-fed agricultural labourer turns out early in the morning, to "attend to his duties" in the fields, often before the dew is off the ground, when the air is most chill, and when the exhalations of the night are most noxious; it cannot, therefore, be wondered at that a large proportion of this class are to be found amongst those who succumb to rheumatism, and its sequels, heart disease and dropsy.

The dark blue places on the map are to be avoided during convalescence, when change of air is required for a rheumatic case; and, again, the map shows us, if it be true that rheumatic heart disease is the most prevalent form of heart disease in England, that districts having the characters which have been set forth as coincident with a high death-rate, should not be selected for residence by those who wish to avoid the risk of contracting a disease to which their bodies are already too prone.

These are two practical points of immense importance to the public at large, but the facts already detailed involve a great many more, which will suggest themselves to those who have enjoyed much experience in their profession.

A grand lesson is taught us by the map of the beneficial effects of free ventilation, and one which we should ever remember when building our streets, our houses, and our hospitals.

I do not think that the influence of the sea winds on the mortality from heart disease is altogether physical, I incline to the view that there is a chemical element as well in operation: I think that probably ozone or peroxide of hydrogen may not play an unimportant part in destroying the material of rheumatism by oxidising it. Therefore in the wards and chambers where cases of rheumatic fever lie, we should not only take care that ventilation is perfect without draught, but that the atmosphere is impregnated with these two powerful gases. Of one thing I am certain, that the removal as soon as practicable of a patient suffering either from chronic or the acute form of rheumatism, to a locality unfavourable for the development of the disease, is quite essential in order to expedite recovery. We have lately had some curious theories with regard to the origin of rheumatism. It would be well for the vegetarian philanthropist, who vaunts the efficacy of celery in this disease as a cure and a preventative, to master the details of the map before you, and select some rheumatic-ridden district where heart disease is rife, and see what can be done to ameliorate the evils that he will find abounding there.

I will now ask you to give me your attention for a few minutes to the subject of the next map—the one on cancer. The results of the heart disease investigation were unexpected enough, but the outcome of the study of cancer distribution was not only unexpected, but startling. No one ever dreamed that this disease had a distribution, and many are sceptical now, but it is impossible to get over the inexorable logic of facts. Throughout the length and breadth of England I found, after mapping the Registrar-General's statistics, that the same kind of localities had the same rate of mortality. This disease, the terrible nature of which has been fatally experienced during the last twenty years by over a hundred thousand women, is one that demands our gravest attention, and every fact connected with its natural history should be sought out, and when found, treasured. The public are much concerned with this terrible malady, for although happily it does not kill so many as some other diseases, yet when we take into consideration how long the disease torments its victims before it finally destroys them, we cannot help regarding it as one of the most terrible afflictions that can be borne by man, and when, too, we know that the rate of mortality among women is more than double that among men, we feel a still deeper interest in this malady, and a keener desire to have all that might teach us to prevent if not to cure it.

Now the facts elicited by geographising the distribution of cancer in females, are simply these. 1st. That the mortality from this cause is highest in those districts which skirt the banks of the rivers of our country which are seasonally flooded. The Thames runs through a vast cancer field; in fact, throughout England and Wales, there does not exist an important river, subject to seasonal floodings, that does not flow through high mortality districts. This was an unexpected fact. Having ascertained it, however, I studied the physical and geological characters of the districts where cancer did not thrive—the bright red districts on the map—and I found that all these districts were characterised by being high and dry, and geologically composed of non-retentive soils—permeable soils and subsoils in fact. After discovering the first fact, it was natural that the second should follow, and so it did.

Those who are acquainted with the physical geography of England and Wales will at once perceive, on looking at the map before you, that the valley districts, through which the seasonally flooded rivers pass, are all coloured in different shades of blue, indicating high mortality; and that the districts lying high and dry on the elevated ground of the country are coloured red, indicating a low mortality from this horrible cause of death. Now from such a map what is to be learnt, not only by the public, but by their advisers, the members of the medical profession? It does not require many words to convince even the most ignorant that it would be utter folly to send a convalescent ague patient into a marshy district for change of air; the thing would seem so absurd, that we should be laughed at even by a fool, for trying to persuade him that it would be wrong. Yet, such things are done in other diseases. The convalescent rheumatic is sent for change of air into some sleepy hollow, where he has a friend perhaps, and then the medical attendant and his patient wonder that convalescence is retarded, and a fresh attack or a relapse perplexes the one, and disheartens the other. We should not send a convalescent typhoid case into the centre of a typhoid field for change of air, knowing the place selected for this change to be a typhoid field. So in cancer; the maps teach us that the high, dry sites on the older rocks are the places where cancer does not thrive, and that it does thrive in the vales by the sides of the large rivers which overflow their banks, and in the neighbourhood of which are to be found the drifts of ages of washings from the inhabited country above. With such knowledge, it would follow that whenever there is a tendency to cancer,

the sufferer should be removed to high, dry sites, and, perchance, if whole families were thus to migrate, we should not have so much of the hereditary character of cancer, or of many other diseases.

We never hear of ague being hereditary. Father, son, and grandson have ague one generation after another, whilst living in an ill-drained fever district, but send them to the hills and their plague disappears; so may it be with the mother, daughter, and grand-daughter afflicted in their lives with cancer, whilst living from generation to generation under the same climatic conditions, on the same geological site, and on the banks of the same seasonably flooded river. It is therefore worth while to try the experiment of emigrating to the higher regions, where the underlying rock easily throws off the rain that falls upon it, and where the natural drainage is all sufficient, especially as these localities are often to be found within a few miles of even the worst cancer fields.

It is a fact, which we cannot despise, that up to the present date we know of no cure for cancer; in fact, so far as treatment or a remedy is concerned, we are simply waiting for some such lucky chance as brought to our hands quinine as a cure for ague. Not being able to cure this dire disease, it becomes all the more necessary that we should endeavour to prevent it. We have, therefore, to discover what localities favours its development, and on the other hand what is the nature of the sites on which it does not thrive. Before the map before you was constructed, no one imagined that cancer had a geographical distribution at all. Moreover, I was the first to prove this point in its natural history, and I did so by carrying out the plan that I adopted in geographising heart disease. I consider the facts most important, and I sincerely trust that the knowledge of them may serve those who either are or may be tainted with this terrible cause of death.

I must now detain you a few minutes longer, whilst I contrast the map of cancer with that of the distribution of consumption in females. Although the facts connected with the distribution of heart disease are remarkable, and were certainly unexpected, yet I think you will agree with me, that the comparison which I shall now make between the maps of cancer and consumption will afford a still more remarkable and unexpected result.

A mere glance at the two maps side by side will at once convince you that the distribution of these two diseases is as different as it is possible to be; for instance, on passing the eye from one map to the other, you will at once be struck with the fact that where there are groups of blue or high mortality in the one, there will be found groups of red or low mortality in the other, or *vice versa*. If we take first the blue cancer fields of the Thames basin, we shall find in the map of consumption a large low mortality area, and the same may be said of all the other cancer fields in England and Wales. Throughout the country the same thing obtains almost without exception. We may summarise the distribution of consumption in England as follows:—

1. The district map before you shows that coincident with sheltered positions is a low rate of mortality from phthisis.

2. The distribution of phthisis is almost the converse of that of cancer, and differs remarkably from that of heart disease.

3. The easterly ridges of the south-east of England are characterised by a high mortality; and this high death-rate is coincident with a general aspect favourable to the malign influence of the east wind.

4. Damp, clayey soil, whether belonging to the wealden, the oolitic, or the cretaceous formations, is coincident with a high mortality, especially in the south-east of England, as shown by Dr. Buchanan.

5. The warm, fertile, and well-cultivated ferruginous red sandstone tracts of country are remarkable for forming the sites of the most extensive series of low mortality groups throughout England.

6. The high elevated ridges of non-ferruginous and infertile carboniferous limestone and coal formations, form the sites of the most extensive series of high mortality districts.

7. The elevated parts most exposed to the westerly and north-westerly winds, and to the easterly and south-easterly, are characterised by high mortality.

8. A sheltered position, a warm, fertile, and ferruginous soil, well drained, are coincident as a rule throughout England and Wales with low mortality from consumption.

None of these facts could have been set forth so as to be grasped by the mind at once, except by such a mode as has been adopted in the maps before you. Any statistical tables would fail to give you an idea of the relation subsisting between the physical geography and geology of the country and the death-rate. Thus it is that, in the distribution of phthisis, and in other diseases, we have to take into consideration other factors besides those of climate and the physical and geological characteristics of the country; and first and foremost among those factors, are the social condition of the people and their employment. Many occupations exert a powerful influence in the causation of phthisis, but these influences are modified greatly by the nature of the sites where those occupations are carried on.

I have thus endeavoured to give you a brief outline of the distribution of those diseases, the maps of which I have published. I ventured upon the task in 1868, with the view of popularising what I then considered, and still think, a most important study. I intended these maps, and whatever I wrote on this subject, not only for the members of my profession, but for the public at large. I considered, and consider still, that such knowledge should not be withheld from the public, and that it should be presented in such a form as to be intelligible to all who might be willing to learn. I believe the facts I have laid before you are within the grasp of almost any intellect. I shall now briefly conclude with a few remarks on some other work I have done in my endeavours to popularise the subject of disease distribution, so that you might see that, even in spite of great difficulties, I have never relaxed in my endeavours to carry out the object with which I started.

I am now painfully aware that I should not have undertaken the task single-handed; it was a task that some Government Department should have taken up. Still, having committed myself to

fied by Francis Galton, is a good example. Here we have a telescope passing through the middle of a circular box, on one side of which is a good azimuth compass with aluminium disc, and on the other a weighted disc for altitudes. Both are graduated and read by a magnifier. These discs may be stopped or liberated by means of thumb screws, A and B. The mode of using the instrument is very simple.

For measuring vertical angles, it is elevated or depressed, with the weighted disc set free, till the object is sighted. The weighted disc, acting like a plummet, retains its position in spite of this inclination of the telescope, but the index reading the disc follows the telescope, and thus shows upon the divisions of the disc the degree of inclination. The disc is fixed by the thumb screw when the object is sighted, and thus the reading is retained for

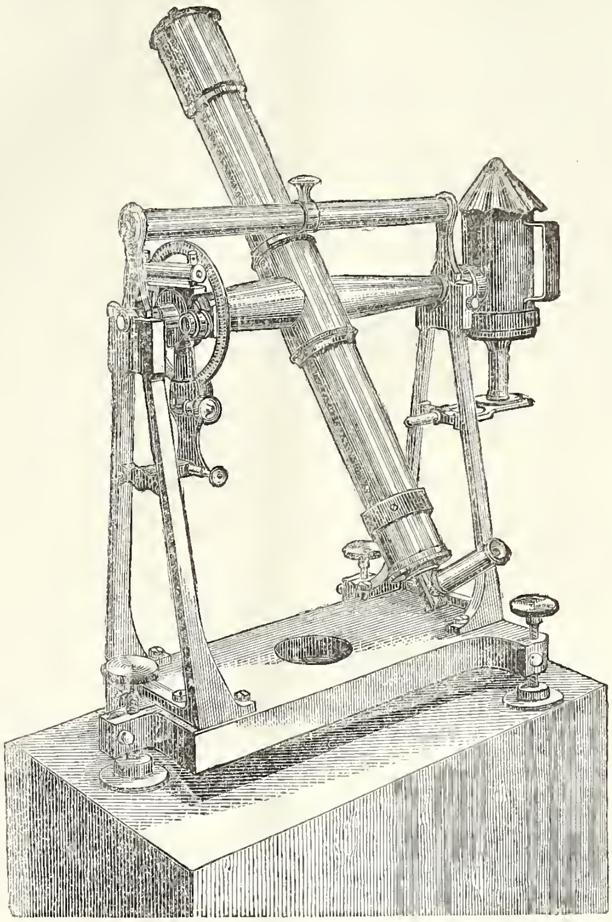

FIG. 17.

deliberate inspection. It may also be read by the telescope upon the edge of the disc while making the observation.

Horizontal angles are measured by turning the instrument, so that the compass disc may be horizontal, 1st., observing an object with free compass, then reading the divisions on the disc; 2nd., make similar observation of second object, and the difference of reading is their angular distance from each other. It is stated, that "a careful observer may read off to tenths of degrees" by this instrument, which only weighs 8 ounces, has a diameter of $2\frac{1}{4}$ inches, and is $1\frac{1}{8}$th inches in thickness.

The prismatic compass is an older and better known instrment of the same class. It measures horizontal angles only by means of a floating compass card, used nearly in the same manner as in Casella's instrument, but instead of the telescope, the reading is effected by means of an upright wire sight on one side, and a prism on the other, which reflects the divisions of the card in such wise that they appear continuous with the upright wire, and are thus read while the object is sighted.

The miner's "dial" is a similar instrument, by which the mining engineer determines the direction of the roads and workings of a mine in reference to the magnetic meridian, and thereby, with the aid of measuring chain, produces a map of its underground mysteries. In doing this, he has to struggle with the interferences which the tram-

ways and other ironwork in the mine, may exert upon the direction of his needle. It is commonly mounted on a tripod stand. The best instruments have a circular rack, and a pinion worked from below, by which the sights are adjusted to their objects. This form is called a "circumferentor."

The clinometer is a very simple instrument, used for roughly measuring the inclination of mountain slopes, dip of strata, &c. In its simple form it is like a jointed rule, with an inlaid spirit bubble and sights on one arm, and a divided arc at the hinge to indicate the angular degree of opening. It is used by setting it level on any available stand, noting the reading when levelled, then opening the hinge until the object is sighted, and reading the difference. These instruments commonly have a scale attached, by which the angles thus ascertained may be reduced, to rise or fall a given number of feet.

The antique "quadrant geometricall" was a very simple clinometer, a piece of wood or other material of quadrant shape, with graduated arc and a plummet. When one of the straight sides, on which sights were placed, was held horizontally, the plummet string followed the other, and read 0; when the side with the sights was elevated, with the arc towards the observer, the string fell upon the graduations of the arc.

Fig. 18 is a *fac-simile* copy of a representation of

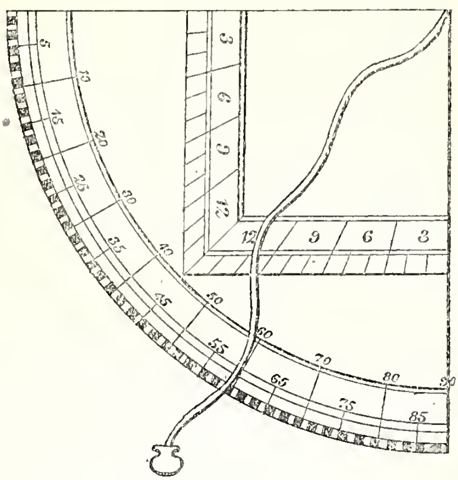

Fig. 18.

"The Quadrant Geometricall," in a curious old work lent to me by the Warden of the Standards, entitled, "A Geometrical Practise, named Pantometria, divided into Three Bookes; Longimetra, Planimetra, and Stereometria, by Leonard Digges, Gentleman, lately finished by Thomas Digges, his sonne. Anno 1571." This book is an admirable epitome of the practical geometry of the period, and abounds in curious illustrations.

I have here the rudest and cheapest instrument now in use. It is a compass in a square box, at the sides of which are bubble tubes and sights. Horizontal angles are measured by taking the compass bearing when one object is seen, and then turning to the other and reading the difference. On the lid of the box is the old "quadrant geometricall," the plummet replaced by a weighted index, which swings freely when the lid is opened upright.

The instrument now bearing the name of quadrant, or Hadley's quadrant, and used at sea, differs materially from the old quadrant geometrically in the principles of its construction. The sextant is essentially the same, but a superior instrument; so much so, that Hadley's quadrant belongs rather to the past than the present generation. It is an arc, or limb, of 60 or 70 degrees, bound and supported by radial and cross bars. Working in the geometrical centre of the arc is an axis that carries an index, bearing a vernier that reads the divisions on the arc. Attached to this is a mirror, standing upright on its edge, with the line or plane of its face accurately adjusted to the zero radius of the vernier. This is called the "index glass." It is shown on Fig. 19, where B C is the arc, E the index or vernier arm, F the index glass. Besides this mirror, there is another at G, which is half silvered and half transparent.

This is called the "horizon glass." It is so adjusted that its reflecting face shall be parallel with that of the vernier mirror when the reading is 0. The telescope carried by the ring L, is attached to what is called the "up and down piece," a stem moving up and down by the screw M; K and N are dark glasses to protect the eye when making observations on the sun; H is the reading magnifier.

The instrument shown in the drawing is called a "pillar sextant," the frame, A A, being double and braced by pillars. Singly framed sextants are strengthened by edge-bars attached to those of the frame.

The use of this instrument is based on the principle that when rays of light strike a flat reflecting surface, they are thrown off or reflected at exactly the same angle as that at which they struck the glass; or, shortly stated, the angles of incidence and refletion are equal. This principle is applied in measuring altitudes by catching the rays from the object on the index glass, and then moving the index until the rays are reflected to the horizon glass, and from thence along the telescope, when the instrument is so held that the reflected object just appears to touch the sea horizon, which is seen through the transparent portion of the horizon glass at the same moment that its reflected image appears in the telescope.

The geometrician will easily see that the total deviation of a ray of light, after the two reflections just described, is just double that of the inclination of the two glasses, and therefore that, when the conditions specified are obtained, the index will be moved from C towards B, just half of the angular distance of the object above the horizon or half of its altitude. The limb is divided accordingly, each degree reading double; the whole 60° or 70° of the arc being divided as 120° or 140°, and subdivided accordingly.

Or the application of the instrument may be be understood thus. Suppose the object to be on the zenith, *i.e.*, 90° above the horizon, we must hold the instrument and incline the index in such a manner that its vertical rays shall first strike the index glass, then be reflected from that to the horizon glass, and thence to the eye; but as the visual direction of objects is determined by the direction in which their rays enter the eye,

it, I have not shrunk from carrying out my original object, and although my work has brought me nothing but labour and anxiety, I still trust it may benefit the public for whom it was intended, and be of some service to my professional brethren.

Since the publication of my work in 1875, I have prepared other maps, some showing the rate of mortality of children, under five years of age, along the coast line of England and Wales, from all causes, diarrhœa and whooping cough. This I showed at Brighton in 1875. I have also prepared maps on the distribution of "Fever," and "Scrofula," and I am now engaged in one on "Diphtheria," which I here present in its unfinished state, and if time permits me to do so, will, with your permission, make a few remarks upon its distribution in the south-east of England. The facts connected with the distribution of that class of diseases, which are called zymotic diseases, cannot be too widely known, and it is evident to me that until the public are educated in the simple principles of sanitary science, we shall fail in our best endeavours to save life by preventing disease. Sanitarians must be helped intelligently by those whom they are trying to help; and this perhaps can only be expected from those who have been plainly and simply taught the principles of the grand science which has so lately sprung up amongst us.

For several years I lectured at St. Thomas's Hospital on the distribution of disease in England and Wales, and illustrated my course by maps of a similar description to those before you. My duties, however, as medical officer of health, prevented my continuing to do this. During this time I was in the habit of showing a map—the fever map which is before you; and it is strange that, long before I was connected with the county of Northampton, I had predicated it as one in which typhoid fever was rife. I had not long to wait to find what I had geographised realised. I illustrated my first report with maps of the distribution of typhoid fever in the county, and showed the difference between the decennial period 1851-60 and 1861-70, in the rate of mortality from this cause. The latter period showed evidence of a marked decline, which, I think, could be traceable to the operation of the Nuisance Removal Acts, which were then in operation. I believe that the next decennial period will show a still further decline. In fact, typhoid fever has no reason for existing at all, but whilst the porous soil of the sites of our villages are being polluted as they are, we must expect well contamination and its sequel —fever. One great source of well pollution which I have known to be the origin of much fever, is the farm yard and its manure heaps. At present the rural sanitary authorities are generally composed of farmers and others, who can not or will not see anything wrong in their barbarous muck heaps. The medical officer of health sees their effect daily. The effect of vegetable decomposition on the human system is varied, but marked. Let us take first the decomposition which produces ague and other forms of fever, as witnessed in the Fen lands, the Pontine marshes, and in other swampy grounds. Or remember the peculiar fever that is the result of living near the localities where flax is steeped and decomposed, or where indigo is allowed to ferment. Then, again, we must not forget that during the American civil war, some few years ago, a form of fever arose, simulating measles, which was traced to the decomposition of the straw on which the soldiers were bedded. It is a curious fact, not perhaps well explained, but still no less a fact, that a soil composed of carbonate of lime favours the decomposition of vegetable matter, and thus it is that these manure heaps, lying as they generally do on open, porous, and calcareous soil, become speedily decomposed, and the poison finds its way into the springs, for it must be known that in the rural districts the landlord has not in too many cases provided for his tenant the necessary receptacle for what his tenant so much prizes, and which would enrich his own land, but complacently shuts his eyes to the evils complained of; and too often at the Sanitary Board meetings has his own way in spite of the self-evident representations of the medical officer of health. I should like not only to see the distribution of disease geographised to a greater extent than it has already been done, but I should like to see the different preventible causes treated in the same way. I should like to see a map of the estates of a given area, or a county, so constructed as to show where there was the greatest number of cases of overcrowding, in consequence of the landlords not providing sufficient room for those who cultivate their estates; and, again, another map, where these wretched farmyards are allowed not only to pollute the air but the water. The estates of those landlords, who really valued the lives and health of those who lived on them, and who considered human beings before their cattle, horses, and pigs, should be coloured in varying shades of red, and, on the contrary, those estates belonging to men who are utterly regardless of their fellow beings, should be coloured blue in different shades, and I feel confident, after many years' experience as medical officer of health, that the disease map and the estate map would remarkably correspond in their colourings. The education in sanitary matters of those who own and of those who cultivate the soil I know to be a hard task. By popularising, however, the principle on which sanitary science is based, I do not despair eventually of teaching something to this large class. Amongst other classes there is a growing desire to acquire knowledge of the laws of health, and I rejoice to think that sanitary associations are doing a vast amount of good by disseminating information on all matters connected with sanitation. In Northamptonshire, the Association of Inspectors which I established in 1873, for the mutual improvement of those officers, has now grown into a Northamptonshire and Midland Sanitary Association, and I feel assured that, by its means, much good will accrue to the public. I have already trespassed too long on your patience, and, therefore, must now conclude, although there are many things that I should like to have said on the subject of disease distribution, but I hope, even in this hasty sketch, I have succeeded in demonstrating how necessary it is that such knowledge should be popularised, that the haunts of fever and other diseases should be deeply impressed upon the mind, and that every effort should be made to search out the resident causes in these localities, and no effort relaxed until these causes have been rooted out.

DISCUSSION.

Dr. Richardson, F.R.S., said that when, some twenty-five years ago, he started the first journal of public health in England, and wanted some one to write a series of articles on the sanitary condition of ancient Rome, he applied to Mr. Haviland, from his having shown, in his collegiate course, a classical knowledge of the history of medical science; and he thus extracted from him his first communication on sanitary science. Probably, through Mr. Haviland being a nephew of Haydon, the painter, some of that great man's genius had descended to him, and he had thus been led to adopt the pictorial method by which he had so graphically put his results before them. He had had the good fortune to be one of the first to be aware of this laborious investigation, and he was almost overwhelmed at the immensity of it for an individual to undertake. As to the merits of the scheme itself, the difficulty, to his mind, always lay in the direction of properly accounting for the facts collected. He did not always see so clearly as his friend did the reason for the facts he adduced. Take the case of scarlet fever. Some years ago, he went over similar ground as Mr. Haviland in using the Registrar-General's returns, to determine at what periods of the year scarlet fever was most prevalent. His analysis went over 46,000 cases, and he came to the conclusion that there was a higher mortality in certain seasons than others; but he found afterwards that there was a certain fallacy in this, because an epidemic might prevail over the whole country in June, with a very low mortality, whilst from a much smaller epidemic occurring in October, November, and December, there might be a very high mortality. In the same way, these maps might not indicate truly the extent of the disease by the amount of the mortality, which might depend on the season, or on some peculiar circumstances in the place. In the map which shows the distribution of heart disease and rheumatism, they were on firmer ground, for there was less reason to suspect variation in the seasons there, nor other cause but locality, as explaining the facts. It was strange how slowly science travelled in these investigations. Up to 1811 he could not trace that any physician had the slightest conception that there was a relation between rheumatism and heart disease. It was, he believed, first pointed out by Sir David Dundas, a retired army surgeon, who lived and practised some time in Richmond, and he left in a short paper nearly all that had since been said as regards the actual connection of the two diseases. Since then, however, they had discovered not only the connection but the reason of it; they knew that the tissues which were affected in rheumatism were histologically the same as those affected in heart disease; the fibrous membranes in the different parts of the body were alike physiologically, in function and in structure, and when there was a certain change established in the body leading to rheumatic disease it was natural that disease should also appear in the fibrous structure of the heart. Some years ago he established an actual synthesis of rheumatism, and showed that the disease could be produced by a particular mode of feeding, the acute symptoms being dependent on the presence in the body of lactic acid, which could be produced by a certain diet. Then came the question why this disease should exist in certain districts, and he did not think there was much room for fallacy here. The disease was known to have a strong hereditary tendency, and this showed it was originally a nervous disease, and that the nervous derangement was central, because affections of the periphery or extremities of nerves were not transmissible, while those which were central were. In this disease, therefore, they had to consider the nervous centres, the ganglionic centres, and the brain and spinal cord; and if it appeared that certain localities were primarily connected with the disease, it would follow that some influence or impression inflicted in the locality produced a nervous lesion, which became transmissible hereditarily. He thought this was possible; but then came another very refined point, what was the nature of this impression. Was it a change which took place through the presence in the atmosphere of some subtle poison. Was there some organic substance floating in the air, which being taken in with the food, or in breathing, set up a change, and produced a specific ferment, from which the lactic acid proceeded; or was it that some simpler natural condition was acting on the body? He suspected it was the latter, and that the primitive cause of rheumatism was damp. The disease could be produced, he had almost said, artificially in the human subject, for he had known it occur in persons living in newly-built, damp houses, where there was no proclivity to it, and then it became hereditary. Some strong evidence on this point had lately come from America, one of the officers in the United States Navy having published a paper, showing that rheumatism and heart disease were more prevalent in ships where the decks were washed than where dry cleansing was adopted. Here one might perhaps find a reason for Mr. Haviland's facts. In the closed valleys he had described there was a large amount of moisture in the atmosphere, which was not removed by currents of air, and this might be the cause of the rheumatism being developed. The next step, therefore, would be to take the hygrometrical relations of these places, and compare the amount of moisture in the air, with that in places free from the disease. On the whole, he thought Mr. Haviland had proved that heart disease was sequential to rheumatic disease, and that rheumatism was connected certain localities. With regard to cancer, he must say the facts were astounding, but the hereditary nature of the disease introduced an important element of difficulty, and the same with regard to consumption. He could not see himself why there should be such marked local difference in the mortality from cancer and consumption, but no doubt the facts might be safely accepted. The mortality in all probability truly represented the prevalence of the disease, and all physicians knew that in some places there was more of one disease than of the other. He knew, before Mr. Haviland's maps were published, that there were certain cancer fields in England; there was one in the centre, and one in Norfolk, as was shown by the number of operations for cancer in the Norwich hospital. Then came the question, what was the cause of this? He had never met with a case of either cancer or consumption in which there was not some hereditary origin. There were certain masked forms of consumption, such as consumption from excessive drinking, or from inhaling dust, a mechanical form of disease, but taking it altogether, it was an hereditary disease, and so was cancer. Then we had to consider whether these diseases were simply propagated, like the people themselves, by intermarriage and descent, rather than by any external local influence. It might be said with regard to consumption that there were some places where it would be most likely to be developed, but to his mind these were not the places shown on the map. The freedom of the sea coast from epidemic diseases was a grand lesson; there we had the widest ventilation nature could give, and a man living on the sea coast was as much protected from currents of epidemic disease as he could be, and in fact had as much advantage over those living inland as one man constantly living in the open air in a town had over another who was always in a house. In conclusion, he wished to say that the doubts he had expressed were not intended to detract from the value of Mr. Haviland's labours, but simply as a guide to further investigation.

Mr. G. J. Symonds, F.R.S., said, with regard to the cancer districts being co-extensive with the area of flooded rivers, there was some hope for the future, in the fact of flooding being diminished, and that, in all

probability, it would, during the next ten or fifteen years, be brought under much better control than at present. Dr. Richardson had thrown out a suggestion that the statistics of mortality in the closed valleys should be compared with the hygrometrical facts in those valleys, and that, no doubt, was desirable. You wanted not only the measurement, which was easily obtained, of the relative amount of wind passing through the valley, but also the humidity of the air. There was one difficulty which he knew Mr. Haviland recognised, and he was sorry that his efforts at improvement were not more successful, viz., the wretchedly arbitrary character of the registration statistics. They were political, or anything, except physical. At one of the learned societies some years ago, Dr. Haviland read a communication, in which he pointed out that, for all sanitary matters, the area should be that of a water-shed. He (Mr. Simons) went into geographical questions from an entirely different standpoint, but he was thoroughly at one with Dr. Haviland upon this, that for all purposes, except, perhaps, political, water-shed areas were the things by which the country ought to be divided. If this division were made in accordance with the physical geography of the country and not in accordance with its political geography, many of the anomalies which still existed on those maps would be cleared away. Another point which struck him with respect to the working out of the statistics, was the fact that some of the healthy areas came out such, he believed, simply because of the tremendous excess of other disease. That was a point which it was not easy to get over; but, clearly, if you divided 100 deaths into per centages, and if you got a large number in the area from any special disease, that immediately made it appear that the area had a diminished amount of mortality in all other diseases. That was a formidable difficulty in this kind of treatment, and possibly it might explain some of the little anomalies which cropped up as to the question of the existence of certain dieases in certain localities. Even an outsider like himself could not help seeing that this was an established fact. Take the extreme case of residents 2,000 feet above the level of the water, on mountains in Yorkshire and Cumberland. There, goitres were as plentiful as blackberries, and it was evidently a case of the geography of disease having something to do with altitude. With regard to the seasonable prevalence of certain diseases, if compared with the death registers, some little complexity would be introduced. At present we had no register of disease, and so long as we floundered about with merely the registration of deaths—which, perhaps, might be better done—we only had part of the truth, and not the whole of it. From what he had said, he did not at all wish to criticise Dr. Haviland's work, but only to point out certain ways in which it might be still further carried on.

Mr. Cornelius Walford said he had treated these matters from a statistical point of view, treating every class of disease with relation to its per-centages in different parts of the country. Some ten years ago, when he first made the acquaintance of Dr. Haviland, these maps came upon him as an entire revelation, for, though quite familiar with the Registrar-General's reports, and with most publications on statistics, he had always found extreme difficulty in localising different districts which were assigned by the Registrar-General. Those districts were perfectly arbitrary, and up to that time he was unable to associate in his mind different districts with different diseases; but the moment he became familar with these maps, the whole thing came clearly out, and, whether in dealing with any particular part of the country, or any particular disease, he found the greatest assistance from these maps. He hoped, therefore, that Dr. Haviland would be sustained in the work he had begun by the moral support of the public. Pecuniary subscription, he was quite certain, had not sustained him. He knew, however, that his works had been very well received in America, though he was sorry to find, from time to time, that some gentlemen here who ought to be familiar with the works, did not seem to be so. He hoped, however, that the reading of this paper would be a great service, and that Dr. Haviland would be encouraged to go on and complete his investigations.

Mr. William Botly said he had taken a great interest in this question for many years. Some years ago he brought forward statistics to show that in villages near Lord Shaftesbury's estate, where he also had some property, the death-rate from fever was much less in villages lying to the south and west, which were more open to the rays of the sun, than in those in the immediate vicinity, which ran in a contrary direction. He hoped the suggestion in the paper would be carried out—that there should be maps of estates as well as of districts, showing the comparative mortality. Some years ago, at the British Association at Exeter, he made a suggestion that it should be compulsory on landlords to have a number of well-built cottages on their estates, which should in no case be less than 20 feet above the water level.

Mr. Ford asked if scarlet fever had been known to deviate from the districts marked on the map, and appear as an epidemic elsewhere, during the 20 years over which the returns extended. He also asked if the maps would be printed in the *Journal*, as without them the paper would lose much of its value.

The Secretary said it would be impossible to produce such maps in time for this week's *Journal*, and the expense would be very great, but no doubt the Chairman man would bring the suggestion before the Council.

The Chairman, having promised to bring Mr. Ford's suggestion before his colleagues on the Council, said—It is greatly to be wished that the paper of Dr. Haviland on the geographical distribution of disease, and the discussion we have had from eminent scientists to-night could be widely published, for it would then be more clearly seen how important is the service of the Registrar-General's department for the careful collection of such facts as those on which the paper and the discussion have been based, namely, as to the causes of the deaths, and their local distribution. Before that registration was instituted, no such investigations—so important to humanity—could have been profitably pursued. Under Dr. Farr, and by his long labours, a new and great public institution has been founded. His quarterly and annual reports are now looked to for the progress of the population as affected by disease, and death, and marriages, and births, with as much interest as the facts about the economical progress of the country, reported in the quarterly returns of the revenue. The quarterly and annual registration reports have been peculiar to this country, and foreign States are beginning weakly to imitate them. The deductions that Dr. Farr gives in them yield but a small part of the results derivable from them, for they provide materials for many of the most laborious investigations. His own conclusions, valuable as they may be, admit of being checked by the facts that he gives; the whole facts serve for independent research and observation such as we have had displayed to-night. Now scientists have heard, with great alarm, that the greatly needed advancement of this work, and even its maintainance in its present state of efficiency, is in danger of being arrested by ill-advised official arrangements. The present Registrar-General, who has given loyal assistance, such as no one else can be expected to give, to Dr. Farr, has announced his intention to resign, and Dr. Farr, who has really done the principal work, has, I am informed, applied for the principal position, as the real Registrar-General, requisite for the completion of the work he has in preparation, including the next census, with improvements on the censuses of the three decades which he has hitherto accomplished, each

with some advance upon the others. Now, we are all here aware of the peculiar qualifications, not merely of medical or of curative science, but of the new sanitary and preventive science, which the supervision of the causes of death, and their classification, as made by Dr. Farr, and now generally adopted in Europe and the United States, requires. We have had experience of the disastrous retrogade effects already produced by ill-advised appointments on merely curative qualifications, without qualifications in preventive science, and we may well be alarmed at the possible intrusion of one who has had no medical training for the classification and appreciation of medical facts as to the causes of death, of one perhaps who, if disposed to learn, has everything to learn, for the due continuance, much less the improvement of the service. I am confident that the appointment of Dr. Farr would, if necessary, have the support not only of our Society, but of the medical authorities of this country, and of the chief scientific authorities of the metropolis. I know that whilst the intrusion of inferior qualifications would be repugnant to him—as an obstruction, that if superior qualifications and the tried and proved special aptitudes needed could be obtained for his assistance, they would have his cordial welcome in any position for the completion and advancement of his work in which we are all so much interested. The Premier has repeatedly declared that the study of the public health is the first duty of a statesman. It is to be hoped that he may be enabled to see the primary importance of the careful collection and classification of the facts on which the success of all such study must depend.

Dr. Haviland, in reply, said he did not know whether Dr. Richardson recollected one incident at the beginning of his investigation; when he showed him his map of heart disease, he said, "Haviland, it is either a lunacy or a discovery." He felt the differences Dr. Richardson had pointed out, especially with regard to scarlet fever, but of course seasonal difference were all merged in the grand total of twenty years. To show those differences would require at least four maps for the same number of years, and no doubt there would be marked differences in the seasons. He had noticed that scarlet fever prevailed most after the autumn gatherings in villages connected with harvest homes, gleanings, and so on, where people from infected districts mingled with others without reference to the diseases they had left at home. He believed that was the reason scarlet fever prevailed more in autumn than at other times. He quite agreed with Mr. Symonds as to the desirability of dividing the district by the water-shed, and had brought the matter before the British Association at Liverpool, but he had been obliged to take the districts as they were in the Registrar-General's returns. With regard to Mr. Ford's question, he might say there was not a single blank place in the map; therefore, scarlet fever had invaded every part of the country, though with different degrees of intensity.

CANTOR LECTURES.

MATHEMATICAL INSTRUMENTS.

By W. Mattieu Williams.

Lecture 5.—Delivered January 20, 1879.

In the last lecture I described the theodolite in the form most commonly used for surveying purposes. There are many patterns and minor modifications of the instrument, but containing the same essential elements. Before describing these, I will explain the use of the vernier, sometimes called a "Nonius," from Peter Nonius, who, in 1542, first enunciated its principle and application in a somewhat complex form, and which was afterwards simplified by Pierre Vernier in 1631. It is a device for subdividing the readings of any given divisions, whether made on a straight or curved edge.

Let us suppose that we have a scale divided to tenths of an inch, we may read it to hundredths by applying to its edge a second scale divided to one more or one less than the primary scale, *i.e.*, to 11ths or 9ths. This secondary scale thus divided is the vernier. It is nsed thus. In Fig. 11 let a and b represent scales divided to $\frac{1}{10}$ of an

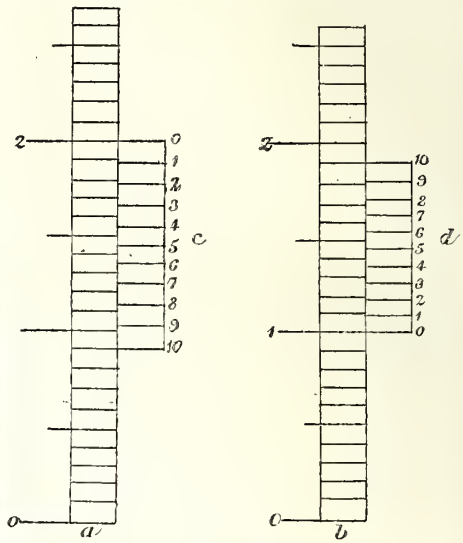

Fig. 11.

inch, and c and d be scales that may slide up and down these; on c $\frac{11}{10}$ of an inch being divided in ten parts, and on d $\frac{9}{10}$ of an inch is divided in ten parts.

Either of these may be used to subdivide the primary scale into hundred. As the two verniers stand in the diagram, c reads two inches and d reads one inch, now that their zeros are respectively opposite the two and the one inch graduations. Let us now suppose that c is moved downwards $\frac{1}{100}$ of an inch. As each division is $\frac{11}{100}$ of an inch, or $\frac{1}{100}$ more than $\frac{1}{10}$, it is evident that this descent will bring the 9th division and the zero somewhere above $1\frac{9}{10}$. We thus get a reading of 1·99 by first looking at zero for the inches and tenths, and then running down till we find a coincidence between the vernier and primary scales which occurs at nine for the hundredths. In like manner, if the vernier descends $\frac{2}{100}$, its division marked 8 will coincide, because in the course of two divisions we have gained $\frac{2}{100}$.

The same applies to the vernier d where each will coincide, and thus read 1·01; if moved up divisions measure $\frac{1}{100}$ less than $\frac{1}{10}$. It now stands to read 1 inch. If moved up $\frac{1}{100}$ its first division $\frac{2}{100}$ its second division will coincide and read 1·02, and so on through all the figures until its zero reaches 1·1, one and one tenth. Then we may go on again and read 1·11, 1·12, and so on.

We are able to see the coincidence of continuous lines with the smallest possible error.

Both of these forms of vernier are based on the same principle. The second system shown on *d*, where the vernier has one more division in a given space than the primary scale and reads forward, is commonly used in modern geodesical and astronomical instruments. In these the ordinary subdivisions are minutes, half minutes, 20 seconds, and 10 seconds.

Thus, if the circle be divided to 30 minutes, and the total reading length of the vernier be equal to 29 of these half degrees, and this length be divided into 30 parts, each vernier degree will be equal to 29 minutes, or one minute less than the divisions on the circle. By using it in the manner already described the instrument may be read to one minute.

The dividing of theodolites and other similar mathematical instruments is, of course, of primary importance. It is by the divisions that the instrument supplies the information it is employed to obtain. Formerly, the divisions were dotted by the beam compass, and then the lines were cut by a graver, or dividing knife, guided by these dots. Graham, whose mechanical ability was of such great service to our astronomer Bradley, expounded and established the fact that you may divide a given line accurately into two parts but not into three or five, and this principle of bisection was applied in all original dividing; that is, dividing directly by the compasses. In the hands of Graham himself, or men endowed with the mechanical skill and mathematical conscientiousness of Bird, Ramsden, Troughton, &c., admirable results were obtained by this method, aided by magnifiers; but such artists as these could only give their work to exceptional and very costly instruments. Others were divided by copying, *i.e.*, laying a standard scale by the side of the work, and, by means of a straight edge, to guide the dividing knife, continuing the standard lines upon the instrument.

Time does not permit any following up in detail the applications of the micrometer microscope, and Troughton's roller, that supplied the place of the beam compass, by travelling round the circle and dotting as it rolled. I can only briefly describe the modern dividing engine, for the principle of which we are indebted to Ramsden.

It is a plate, or table, mounted on a vertical axis, and thus rotating horizontally. Its edge is cut with teeth, upon the equality of which the accuracy of the instrument depends. These work in an endless screw arranged tangentially to the rim of the plate, and thus at each whole turn of the screw the plate is turned the distance of one tooth. Thus, if there are 360 teeth, each turn of the screw moves the plate one degree, and every fraction of the screw's rotation gives a corresponding fraction of a degree. The plate or arc to be divided is fixed concentrically with this plate, the machine is adjusted to turn the screw through the required distance and then halt, while the dividing knife makes a stroke. Straight-edge scales are divided on the same principle.

In the manufactory of Messrs. Troughton and Simms, at Charlton, there are engines of this kind of different sizes to suit different work, all beautifully constructed. I saw one driven by the shaft of a steam-engine, that was doing much other wonderful work at the same moment, and when I beheld it thus moving like a living creature, and performing this difficult operation with superhuman ability, no human being but myself, a passive spectator, being near it, I was overwhelmingly impressed by this striking demonstration of the marvellous progress we have made in the mechanical arts since the predecessor of the present proprietor of these works received the Copley medal of the Royal Society in 1809, for his improvements on Graham's tedious method of perpetual bisection.

At the same works I saw almost every operation that, during my apprenticeship, I had learned to do with plane, file, and foot-lathe, now performed far more accurately by automatic machinery, the details of which would demand another half-dozen lectures to describe.

But far more satisfactory to me than all these evidences of physical progess was the evident moral and intellectual superiority of the workmen to those among whom so many years of my own boyhood was miserably spent. While mechanical skill is so far superseded by these devices, a demand for higher intellectual effort and moral stability is created by the present necessity of understanding, controlling, and supervising such machinery. The hours of labour, which during my apprenticeship were from 6 a.m. to 8 p.m. in summer, and 7 a.m. to 8 p.m. in winter, with two hours interval for meals (*i.e*,, half-hour for breakfast, one hour dinner, and half-hour tea), are now considerably shortened, and the wages 25 to 50 per cent. higher; while bread, clothing, groceries, and nearly all provisions are much cheaper.

I step aside to mention these facts based on direct personal knowledge, because they refute the mischievous fallacy which asserts that machinery only benefits the capitalist. All who, like myself, can practically compare the past with the present condition of the workmen, in any decidedly progressive trade, may offer similar testimony.

On the back of the semicircles of most theodolites is another series of graduations, with the inscription, "Difference between hypo and base," or "Difference between hypotheneuse and base." This is used when chain measurements are made in ordinary surveys over hilly ground. The slope of a hill may be regarded as the hypotheneuse of a right angled triangle, of which the horizontal distance to any given point on the slope is the base, and a perpendicular from that point is the perpendicular. The relation of the hypotheneuse to the base of a right angled triangle is an easily determined quantity, dependent upon the angle it makes with the base. Thus, knowing this angle, the difference can be stated in figures, and as the semicircle shows the angle when the surveyor makes an observation from one end to the other of any given chained distance on a slope, the semicircle can be made to tell the surveyor the figures by which he may at once reduce his slope measurement to horizontal measurement.

The instrument I have here (and shown on Fig. 12) differs considerably from that already described, though the principles of its construction and use are precisely the same. It was designed by Captain Everest, and several were made by Messrs. Troughton and Simms, about 1838. These were all bronzed, and it was these to which I alluded in the last lecture as commencing the era of black instruments.

The parallel plates of our typical instrument are

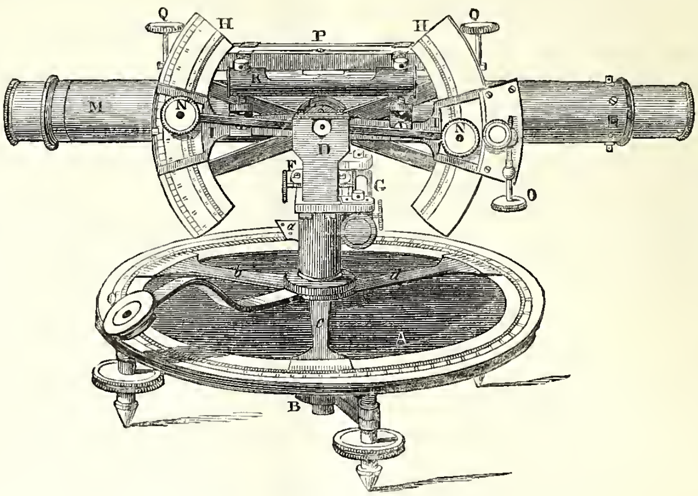

Fig. 12.

represented here by a tripod, which works in the stand (Fig. 13), which may be screwed to the table-plate of a staff-head, like the instrument already

Fig. 13.

described, or may be placed upon a table, parapet, or any other convenient support. This is one of the advantages of the instrument. The adjusting screws of the tripod work in a bevelled depression in the stand, into which they are placed by turning the locking-plate, B (Fig. 13), so that the round part of its three terminal holes shall stand over the bevel. Then the locking-plate is turned to the position shown in the drawing; the spring, C, catches, and the tripod is held down by the flanges below the screw heads.

The horizontal circle or limb is single. The vernier plate is represented by four radiating arms, three being verniers, the fourth with clamp, and tangent screw (not seen in the drawing). These are connected with the telescope, &c., and turn with it to measure horizontal angles, which are read by the three verniers with the aid of an independently moving magnifier, C. The mean of three readings is thereby obtained for each observation, instead of two as an ordinary theodolite.

This instrument has the power of repeating, by clamping the arms to the limb, and then turning the limb upon its axis at B, back to the starting object; clamping the limb to the stand, and then starting again, as described in the last lecture.

The mounting of the telescope is quite different from that of the common theodolite. Instead of being soldered to collars, which rest moveably and reversibly on Y's standing on the vertical limb and horizontal axis, the telescope is here permanently fixed to the horizontal axis, by means of a collar-like expansion at the middle of the bell metal axes, into which the telescope is screwed or soldered, at about mid-length or balancing length.

The vertical limb, which has a double arc, H H, Fig. 12, is also fixed to this axis, so that telescope and limb move together, as in the common theodolite. The horizontal axis works in a Y-shaped upright D, held in by a moveable clip.

An index upon this axis carries the verniers, I I, and a spirit-level, K, by means of which the index can be set horizontal. When this adjustment is made, and the telescope raised or depressed, the arc moving with it, the mean of the two opposite readings on the arcs will give the elevation or depression from the horizontal plane.

The bubble for the limb is attached to the stage below the Y's, and the circular compass-box of the ordinary instrument is substituted by a long compass-box placed above the telescope, and only reading a few degrees east or west of the magnetic meridian. These are sufficient, inasmuch as the magnetic bearing of any object is obtainable by turning the telescope until the needle points to zero, and noting the reading on the limb, then turning the telescope to the object, and reading the angular difference on the limb.

To set the limb of this theodolite level, first bring

the bubble, G, parallel to two of the foot-screws, and by them bring the bubble to the middle of the tube, then turn the telescope, level, &c., half round, and if the bubble has run to either side, correct half the deviation by raising or lowering one end of the level itself, and the other half by the foot screws. Then turn the telescope, &c., a quarter round, thus placing the level in position corresponding to the second level on the plate of the common theodolite, and adjust again in this position by means of the third foot-screw.

Thus one bubble does the work of the two on the common theodolite plate by a double adjustment. The collimation adjustment is not so simple in this as in instruments with collars turning in Y's. It is attained, however, on the same principle of turning the telescope round, and observing whether the collimating wires retain their position relatively to a distant object. This turning is done by lifting the telescope and its appendages bodily from its supports, and turning the axis end for end, dividing the error on the same principle as described in the last lecture.

The horizontal datum or zero of altitude is obtained, by taking the altitude or depression of an object with the vertical sector in reversed positions; half the sum will be its true altitude or depression. Set the verniers to this, and again observe the object making its bisection by means of the screws which retain the index in its horizontal position, then correct the level by its own adjusting screws.

The transit theodolite shown in Fig. 14 is similar

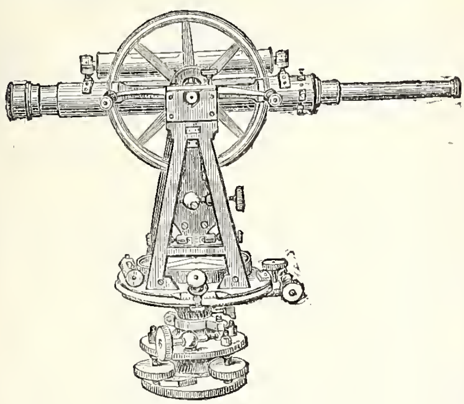

FIG. 14.

to the Everest, in having its telescope fixed directly upon the horizontal axis, while it resembles the common or Y theodolite in the arrangement of the plate and limb, in the manner in which the uprights are fixed to the plate, and the direct attachment of the level to the telescope. The vertical limb is a complete circle, allowing the use of two or more verniers. Its collimation adjustment is similar to that of the Everest, and the other adjustments nearly the same as the Y theodolite. The advantages of this form of theodolit e are the greater vertical sweep of the telescope and the greater accuracy of the readings of the vertical arc. A diagonal eye piece is usually added for showing great altitudes.

Large station theodolites like that from India, shown at the last lecture, are constructed on this model slightly modified.

I have here several photographs of some very fine instruments, recently constructed by Messrs. Troughton and Simms, one of which is shown from different positions by Figs. 15 & 16 (p. 170).

In these instruments the uprights are made of great solidity and considerable weight (portability not being a desideratum) to give steadiness to the telescope. Compound microscopes are used for reading; and the axis is perforated in order that the webs may be illuminated by a lanthorn placed before its perforation. This is for night-work.

When used for astronomical purposes, for which they are thus fitted, they are sometimes designated altazimuth, or altitude and azimuth instruments. The altitude of a star or other celestial object is its angular height above the horizon, which this instrument measures at once by starting from the horizontal position indicated by the telescope level, and reading on the vertical circle the angular distance above this when the object is in the optical centre of the telescope.

The azimuth of a star, &c., is its horizontal angular distance from the meridian of the observer, *i.e.*, from a line or plane stretching from north to south. It is obtained by setting the instrument so that the telescope sweeps due north and south, and then reading upon the horizontal limb the angular distance the telescope has travelled east or west when the object is observed.

This 2½-inch "baby theodolite," I may call it, is constructed on this model. It is made by Mr. Casella as a portable altazimuth instrument for the use of travellers, by the aid of which an explorer may take the astronomical observations necessary for determining his whereabouts, &c., and may also use it for geodesical purposes as a theodolite. Only approximate accuracy is attainable with so small an instrument, which is intended for use under circumstances where larger cannot be carried.

Large altazimuth instruments are constructed with the telescope between two vertical circles braced together and standing on strong pillars.

The transit instrument (Fig. 17, p. 171), is a telescope mounted in such wise that it shall make a vertical sweep with the utmost possible accuracy, the instrument being so placed that this sweep shall be in a plane which, if continued, would cut the earth into equal halves from pole to pole, or describe by its edge a celestial circle, stretching over the heavens in a line due north and south. Every visible star must cross some part of this circle once in the course of a siderial day, and this crossing is called its meridian transit. Astronomical time and terrestrial latitudes are determined by such transits.

I cannot enter upon the details of the construction and adjustments of these instruments, but must refer to one fundamentally essential, upon which the accuracy of all the transit class of instruments depends. Under "transit class" I include not only the transit theodolite (of Fig. 14), and the altazimuth instrument (of Fig. 15 & 16), but all those which the telescope is fixed to the horizontal axis, in and is collimated by reversing this axis. It is that of the equality of diameter of the pivots upon which this axis turns. In the common theodolite,

a slight inequality of these would not be serious, provided their bearings were horizontal, for after the constructional adjustments of the instrument maker are completed, this axis is not again dis-

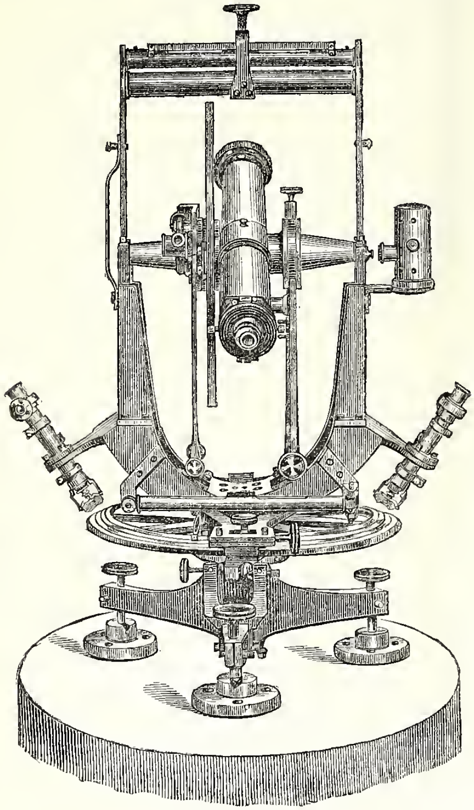

Fig. 15.

turbed. In the transit class, as I have ventured to call them, reversal of the axis is an essential feature. In some of the larger instruments, too heavy to be lifted by the hand, a reversible stand, a sort of turn-table, is constructed for the purpose. One of these, by Troughton and Simms, is shown among the photographs.

In these instruments platinum wires are commonly used instead of spider webs. Wollaston invented a very ingenious method of drawing such wires. He took a piece of platinum wire, the finest he could obtain by direct drawing, stretched this down the middle of a mould, as the mould candle maker stretches his candle-wick, then poured into the mould melted silver, as the candle maker pours tallow or paraffin. He thus obtains a cylinder of silver with a platinum wick $\frac{1}{20}$ of its diameter. This compound wire was drawn out again, the platinum and silver still maintaining their relative diameters. The removal of the platinum core was easily effected by immersing the compound wire in nitric acid, which dissolves silver but not platinum.

The transit telescope has a grating of wires, five, seven, or other odd number, vertically stretched. As the earth rotates, carrying the telescope with it, the rays or image of the star travels across the field of the telescope. The moment of its crossing the wires, or especially of the middle wire, is noted by the observer by counting the beats of a clock, an

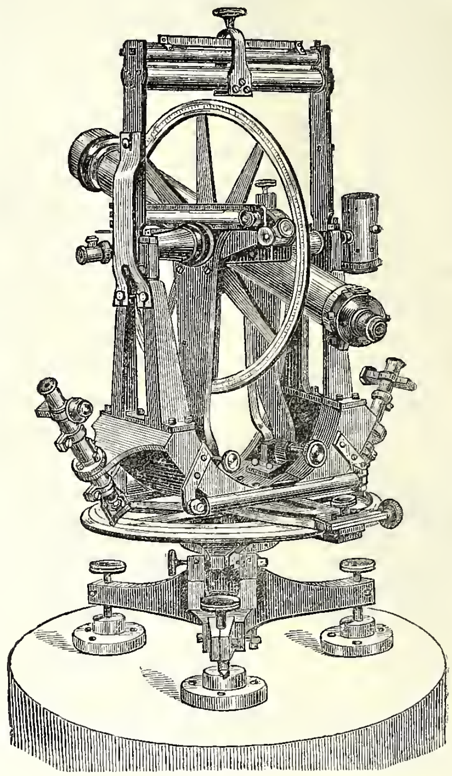

Fig. 16.

operation which, as explained in the first lecture, cannot be performed by anybody without either delay or anticipation, according to temperament, which error has to be assimilated to somebody else's error by the aid of personal equations.

The chronograph has reduced this source of error to a barely appreciable quantity. Aided by this instrument, the observer's attention to the star is no longer distracted by his watching the clock or counting its beats; he simply places his finger on a button, and when the star touches the wire, he presses the button. This button is electrically connected with a ribbon made to travel by the clock over a certain distance during each second, which distance is pricked off the ribbon by the clock at every second, except the sixtieth, thus leaving a double space to mark the minutes. This ribbon is also marked by electric transmission of the observer's touch, and the position of this mark indicates the moment at which his finger pressed the button.

There are many substitutes for the theodolite, *i.e.*, instruments of less cost, which measure horizontal or vertical angles with inferior approximations to accuracy. Portability, rather than cheapness, is in some cases the chief desideratum.

Casella's pocket altazimuth, improved and modi-

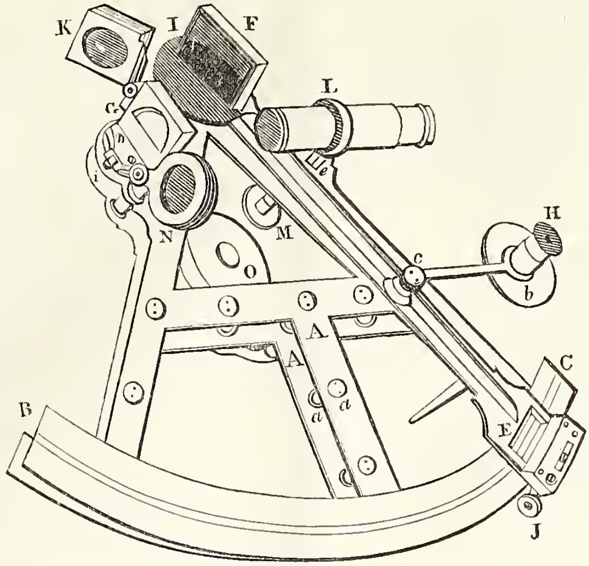

Fig. 19.

this second reflection must be in a horizontal direction in order that the second reflected image shall appear upon the horizon. Now, this horizontal line is, of course, 90° from the original vertical line, 45 due to the reflection of the index glass, and 45 to that of the horizontal glass, and to get these two 45° the glasses must have an inclination of 45° to each other. The same applies to any other angle.

Horizontal angles may be measured on the same principle, by making the reflected image of one object appear to touch the direct vision object of the other; this apparent contact, like that with the sea horizon, being made to take place just where the reflecting portion of the horizon glass meets its transparent portion.

This horizontal angular distance is, however, only correctly shown thus simply when both objects are in the same horizontal plane, like two objects on the sea. If this is not the case, a correction must be made according to their difference of altitude.

I need scarcely add that the tangent screw, J, is for fine adjustment, and acts on the same principle as that elegant device in the theodolite and other instruments.

The box sextant is a charming little instrument, constructed on the same principle as the Hadley's sextant, and is chiefly used for terrestrial surveying. It requires no stand, and, when closed, is merely a box about 3 inches in diameter, and 1½ to 2 inches deep.

In Fig. 20, A is the index which is moved along

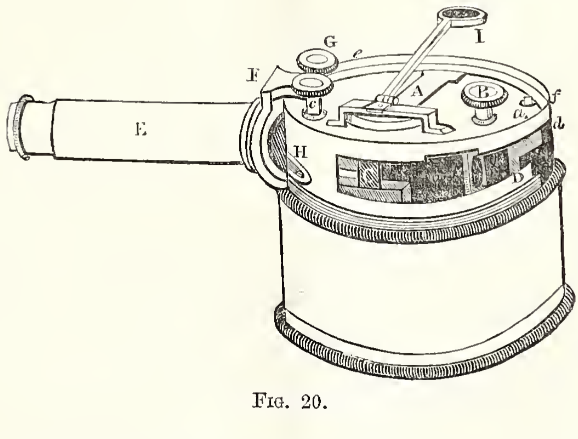

Fig. 20.

the divided limb, *e f*, by a rack and pinion concealed in the box, and turned by the milled head, B. The glasses, C and D, are within the box, and their adjustments firmly secured; I is the magnifier for reading the divisions. In this figure the lid of the box is shown screwed to the bottom, so as to form a sort of handle. The limb is numbered both right and left.

The principle of construction, and use of the box sextant, is the same as of the Hadley's sextant. It is chiefly for land surveying, and therefore its application to horizontal angles is the most important.

In measuring these with either form of sextant, the two stations, or objects between which and the observer's eye the angle is to be measured, must be brought together on the horizon glass just as the sun is brought upon the horizon in ordinary nautical observations.

The illustrations for this lecture were—5-inch theodolite with trough needle, 5-inch Y theodolite, circumferentor, box sextant, prismatic compass, reflecting clinometer, rule patten clinometer, clinometer with levels, sights, and compass, from Messrs. Troughton and Simms, who also lent the blocks for the engravings of the different forms of theodolite, sextant, and box sextant, by which the report of this and the previous lecture are illustrated; a pocket altazimuth, Hadley's sextant, miner's dial and clinometer, from Mr. Casella.

MISCELLANEOUS.

LOCAL MUSIC SCHOOLS.

Yorkshire has established a Training College of Music, in union with Trinity College, Weymouth-street, London, W., with a local organisation of its own. The musical director is Mr. J. Sidney Jones, and the hon. secretary and deputy-treasurer, Mr. J. W. Foulston. The head-quarters are in Victoria-square, Leeds.

The prospectus announces that the primary aim of the Yorkshire Training College of Music is to popularise musical study on correct principles. Fees are to be paid, and there are to be "Free Scholarships."

The objects are stated to be—1. To develop musical talent, particularly among the labouring class. 2. To furnish facilities for musical enjoyment without danger to character and prospects. 3. To stimulate a taste for, and the study of, high class music. 4. To encourage native talent in its efforts to produce original compositions. 5. To improve congregational singing. 6. To teach solo and part singing. 7. To cultivate orchestral playing, and, as soon as possible, organ playing. 8. To increase home happiness. 9. To systematise musical study by means of graduated classes, thereby imparting a musical education—theoretical and practical, vocal and instrumental.

It may be suggestive to other local music schools in contemplation to know what the fees are. Quarterly, and paid in advance—first grade, elementary instruction (in class), vocal or instrumental, 5s.; second grade, elementary instruction (in class and apart), vocal and instrumental, 10s.; third grade, advanced students (in class and apart), vocal or instrumental, 15s.; fourth grade, advanced students with the addition of harmony and counterpoint, £1 1s.; fifth grade, composition, history of music, choral and orchestral conducting, &c., £1 10s.; sixth grade, the highest attainments in music: analysis of classical works of the great masters, ancient and modern; papers on style, with illustrations; executant skill and excellence in composition will form the chief characteristics of this stage of study, £2 2s. N.B.—A class for children is formed (time—3 o'clock on Saturday afternoons), 5s. Lectures on musical subjects will, from time to time, be delivered.

The privileges of subscribers and donors are as follows:—1. Free admission to all concerts by the students, and to the lectures, 10s. 6d. annually; 2. Free admission with a friend, and one vote for a free scholar, £1 1s.; 3. Free admission with two friends, and two votes for a free scholar, £2 2s.

The College was opened on March 14th, 1878. The number of students already entered, males and females, number seventy-five.

Although no provision is named applicable to training teachers for elementary schools, which is the basis of National Musical Education, no doubt arrangements will be made.

It is hoped that the Education Department is alive to this and other evidences of the growing demand for musical education; and will announce this year such modifications of the Code referring to singing in elementary schools, as will utilise to the fullest extent the large amount (exceeding £95,000) already paid in respect of this "singing by ear."

ON THE EXTENDED CULTIVATION OF THE SINGHARA NUT IN INDIA.

The question of the prevention of famines in India is one that has occupied the attention not only of private individuals, but of Governments also. To discover a satisfactory solution to this difficulty would be to confer an extraordinary benefit upon our Eastern Empire, and some such solution is supposed to have been found by a Captain J. F. Pogson, who, in an paper contributed to the "Agricultural and Horticultural Society of India," proposed the much more extended cultivation of the plant, producing what is known as the Singhara nut (*Trapa bispinosa.*) This plant is a close ally to the celebrated Chinese Ling (*Trapa bicornis*) which the Chinese utilise to a very great extent, for with them the kernel or seed forms an important article of food, so that the plant is largely cultivated. The European species (*Trapa natans*) is called in France water chestnut, and the farinaceous fruits are sold in the markets. Of this species, Captain Pogson says:—"It is highly probable that the first food-producing plant, cultivated by man after the Deluge, and before the soil had been sufficiently sweetened to grow rice, wheat, and other cereals, was the *Trapa natans.*" The discovery of these fruits in a very perfect state of preservation amongst other vegetable products in the lake habitations of Switzerland, prove that the plant was cultivated in Europe in early times. Pliny, who wrote on the subject some eighteen hundred years ago, states "that the Thracians made bread of them," and as the modern inhabitants of many districts in Southern Europe to this day convert the kernels into meal, and with it, after suitable manipulation, make and bake very good bread, the value of water chestnuts may be considered as fully and fairly established.

The singhara of India, which has been referred to *Trapa bispinosa*, flourishes in the lakes of Cashmeer, and also in the ordinary tanks all over the Upper Provinces of Bengal. The owners of tanks under Singhara culture derive a very handsome annual income from their property, and to prevent the extension of this profitable cultivation they have caused European inquirers to believe that the shortest way to fill up a tank (irrespective of its size and depth of water) is to plant it with water nuts.

The jheels and tanks in which the singhara is grown, almost as a rule, contain some sort of fish, and these are netted either by the lessees for their own benefit, or else for that of the proprietor, who remunerates them for their labour. The palku bearers of Bengal proper Oudh, North-West Provinces, and other parts of the country are not only agriculturists, but load-carriers. The *banghy* of the *Kahar* requires no explanation. With

it he carries the traveller's *pittaras*, or, when occasion requires, cow-dung, cake, fuel, mangoes, fish, and singharas. He is a proficient in the art of making net work, or twine, stout string, or half-inch rope. If fish are to be had in his neighbourhood for the catching, a cotton string net, with mesh of suitable size, is soon forthcoming, and he increases his income by catching and selling the fish. The genuine fisherman, by caste and hereditary avocation, is called a *Mutchwa*, a term never applied to the *Kahar*, who, when enlisted, makes a brave and gallant Sepoy, and when utilised as a camp follower carries hospital *doolees* under fire, and the sick to hospitals in cantonments. Of all the castes of Hindoos the *Kahar* is the most useful and easily managed. He will serve in any part of Hindostan, and if the project of systematic singhara cultivation is carried out, the employment of *Kahars* as workmen and practical instructors will have to be adopted.

The great difficulty the Government of India has to contend with is not so much famine as the habits and customs of the population. In Bengal proper and Madras the people live upon boiled rice, and decline to use leavened and unleavened maize, millet or wheat bread. In the Punjab, rice from Bengal would be of little use in relieving a famine, for without wheat and millet bread as a stand by, the stalwart Punjabee would lose flesh and muscle, and suffer from innutrition. In the Himalayas, maize meal bread is the daily food of the labouring and agricultural classes, boiled rice with sugar and *ghee* or *dhal* is for high days and feasts of honour, and not for hard hill-work, which the rice-eating Bengalee could no more undertake than a Tibetan goat could carry the load of a mule. The good folks of England have been greatly puzzled at India exporting immense quanties of wheat *viâ* the Suez Canal, whilst a famine was raging in the Presidency of Madras, and they would no doubt be quite bewildered if Bengal and Madras sent shiploads of rice to the United Kingdom during the prevalence of a famine in the North-Western provinces of Oudh.

The explanation given is intended te convey to the mind of the British public that there is always an ample supply of food grains in Hindostan. But if millions will starve rather than eat bread, and others languish if placed on rice, the consequences rest not on the Government but the people.

Captain Pogson further considers that in order to meet future famines, the singhara should be extensively cultivated, no other food crop, in his opinion, being available to meet India's wants, because "the rice-eating millions of Bengal and Madras will eat these tasty and nutritious nuts with pleasure if they be available, and the bread-eating millions will do the same. The beds and bottoms of lakes, jheels, inland fresh water seas, and vast reservoirs yet to be made have only to be planted or sown with the matured nuts to bear immense crops on the water's surface, and as the harvest or season lasts for three months, starvation from famine ceases to be a menace; finally, as the dried nuts will keep good for years, and may be easily stored, the maximum and surplus of extra wholesome food is secured at the minimum of cost."

The nuts can be stored either in the horny outer skins, in which state they will keep good for years, or else the kernels taken out and sun-dried, and in this state they can also be kept for a long time.

The scheme of Captain Pogson is, to say the least, an interesting one, and, if carried out, would, by putting more food material at the command of the people, help in some degree to alleviate the frightful effects of famine.

The shipments of Ceylon ebony have varied very much in the last few years. In 1874, they were 29,176 cwts.; in 1875, 15,750 cwts.; in 1876, 9,007 cwts.; and, in 1877, 20,797 cwts.

FIRE AT THE SOUTH KENSINGTON MUSEUM.

The *Athenæum* publishes the following in correction of some assertions about the insecurity of the Museum:—Mr. W. Allingham writes to the *Athenæum* of the 18th of Janury asserting that "the South Kensington Museum runs a great chance of destruction by fire"—a loose and inaccurate statement. If he will inquire of the secretary at Whitehall he will learn that all the permanent buildings of the Museum are essentially constructed of brick, slate, iron, and terra-cotta, and that where there are floors, they are of tile, iron, and concrete; that the water, always at high pressure, is laid on throughout the buildings; that large tanks, always filled, are in the roofs; that a register of the pressure is kept, and whenever it falls short the water company is admonished; that the police patrol the building all day and night; that they record their watching at night on tell-tale clocks, and that fire buckets are always filled; that twelve sappers and miners of the Royal Engineers reside at the Museum and have charge of the fire and water arraugements, in which they are constantly practised; that they can be assembled in less than five minutes, in any part of the building, at any time of the night. Except some woodwork in the roofs of the earliest-built portions of the Museum and the wooden frames of the glass cases, the books, and the few specimens of woodeu furniture, there is next to nothing that can be burnt. Fire is absolutely defied. If the rules are properly carried out for which I was responsible for more than twenty years—and I have no reason to doubt it—the South Kensington Museum may be said to have not a "great," but the least "possible chance of destruction by fire."

Henry Cole.

THE TELEPHONE IN AMERICA.

The *Scientific American* gives the following account of the extension of telephonic systems in America:—The Philadelphia Local Telegraph Company has perfected an arrangement putting their clients in the various parts of the city into immediate telephonic connection. This is done by means of an ingenious telephonic switch board recently devised. As described by a local paper, the front of the apparatus consists of a walnut frame and bright strips of brass, punctured with holes, into which wires are fitted to make the necessary connections. Behind this all the wires converging in the office concentrate. The board when put in operation accommodates no less than 400 different lines, which have an aggregate length of 1,000 miles, thus placing each firm or individual having telephonic connection with the main office in direct communication with 399 other persons scattered over the city. Should an individual at the Baldwin works desire to converse with a person at Cramp's shipyard, he ascertains from a printed card the number or call of the Kensington ship-builders. As an instance, if the number of the Cramp telephone is 12, the speaker at Baldwin's touches a spring attached to his instrument to designate the number, and immediately a bell at the central office rings out the signal, and simultaneously a little tablet on the switch board drops and reveals the name of Baldwin and Co. An attendant sees at a glance that someone at Baldwin's desires to talk with No. 12, and, finding this to be the box at the Cramp yards, connects the wires of the two places, either by means of the pins referred to, or by joining them to a rod fixed in the back of the switch board. Now, the man at Baldwin's practically has his mouth to the ear of the persou at Cramp's, and can talk to him about the weather, or the price of steamships, or order some machinery, or invite him to dinner, as he chooses.

If he wants some article which the shipbuilder cannot supply, they may recommend him to one of the other 398 establishments connected with the telephone exchange, and, by going through the same simple process, he can order coal at Port Richmond, call for cars at Washington-street Wharf, send for a man at Manayunk, and, in fact, can talk with a dozen individuals in as many distant points in less than that number of minutes. The instrument is so arranged that any number of persons can talk on as many subjects at the same time, from different points, without experiencing the difficulty that occurred at the building of the Tower of Babel.

Telephone circuits, working substantially similar to the above, are now in operation in the principal cities of the United States.

THE FERMENTATIVE POWER OF THE PAPAW.

The question of the fermentative action of the juice of the papaw *(Carica papaya)* upon animal tissues has received some confirmation from the experiments of Herr Wittmack, which he recently embodied in a paper communicated to the Natural History Society of Berlin. The juice, as obtained from the fruit, is of a white milky character. and is present in the fruit apparently only in small quantities, for Dr. Wittmack obtained, after repeated incisions made in a half-ripe fruit, only 1·195 grains of the milky juice of the thickness of cream. When dried it has a strong odour and flavour of petroleum or vulcanised india-rubber. In the experiments some juice was dissolved in three times its weight of water, and some fresh lean beef boiled in it for five minutes. Below the boiling poiut the meat fell into pieces, and at the close of the experiment it had separated into coarse shreds. Fifty grains of beef in one piece, enveloped in a leaf of the papaw and left in this position for a period of tweuty-four hours, at a temperature of 15° C., became perfectly tender after a slight boiling, while on the other hand a piece of meat of similar size and weight, simply wrapped in paper and heated in the same manner, remained quite hard. The experiments prove that in the milk juice of the papaw a ferment resides which has a powerfully energetic action upon nitrogenous substances, and it is to this action that the peculiar and well known property of the papaw is attributable.

SELF-ILLUMINATING WATCH FACES AND CLOCK DIALS.

M. Olivier Mathey, a Neufchâtel chemist, and the manufacturer of the well-known "Diamantine," communicates the following information in regard to the composition of these dials, to one of our foreign exchanges:—

Phosphorescent dials are usually made of paper, or thiu card-board, enamelled like visiting cards. They are covered with the adhesive varnish, or with white wax, mixed with a little turpentine, upon which is dusted, with a fine sieve, powdered sulphide of barium—a salt which retains its phosphoresceuce for some little time. The sulphides of strontium and calcium possess the same property, but lose it more quickly than the former. After the dial has remained in darkness some days it loses its phosphoresceuce; but this may be readily restored by exposure for an hour to sunlight; or, better still, by burning near the dial of a few inches of magnesium wire, which gives forth numerous chemical rays.

M. Recordon, of Paris, states that two years ago he took out a patent for, and has since been manufacturing, illuminated dials, on an entirely different principle from those produced by the use of chemicals. His device is this: A Geissler tube, containing a gas which gives a brilliant light, is placed on the dial; a battery about the size of a thimble is attached as an ornament to the watch-chain, aud a miniature induction coil is also hidden in the latter. When it becomes desirable to consult the watch in the dark, a spring is pressed, the current passes into the coil, then into the Geissler tube, and illuminates the dial. The portable battery used for this purpose is that of Trouvé, which, in a small compass, has considerable strength. Reduced to the size of a thimble, it is still sufficiently strong in its action to last a year. Mons. Recordon also applies the same principle to the illumination of clock faces.—*The Watchmaker.*

THE IMPORTS OF CAOUTCHOUC IN 1878.

From Messrs. Hecht, Levis, and Kahn's caoutchouc report for 1878 may be learnt something of the state and fluctuation of the rubber market during the past year. Like every other branch of trade this special market was, to a certain extent, influenced by the general depression. The imports of rubber, except those of the West Indian kinds, were on a liberal scale, and there was a steady consumption throughout the year. Of Para rubber it seems that the imports into London were larger than in previous years, and the total consumption of this kind exceeded that of last year by 500 tons. The price of this kind fluctuated considerably during the year from 1s. 11½d. per lb., in January, to 1s. 8d. in April, increasing towards the end of the year to 2s. 0½d. in December. A similar fluctuation occurred in negro-head from 1s. 2d. to 1s. 5¾d. per lb. Of *Ceara scrap*, 60 tons were imported, and it is said that this kind continues to be neglected. The imports of Guayaquil and Carthagena sorts amounted to 150 tons. The continued decline in the supply appears to partake of a permanent character; consequently high prices ruled, especially for pressed. African showed 1,000 tons imported. All kinds of African, it seems, were in good demand, and met with a ready sale all the year round. Thimbles, in spite of occasionally very high rates, were in great favour, and were eagerly sought after. Assam was neglected at first, but attracted more attention towards the latter part of the year. Of the Borneo kind, the quality was on the whole more satisfactory than in former years, and the price hardly varied during the year. From Rangoon, Singapore, Penang, and Java, the imports were small, but readily taken at fair rates. The supplies were small of the Madagascar kind, and the quality was not uniformly good, and consequently not always saleable. The quality of Mozambique was occasionally irregular, but the increased imports were readily disposed of. Of West India *Sheet* aud *Scrap* it appears that the imports of this favourite kind fell off considerably. The prices ruled very high all the year, in consequence of this scarcity, which seems likely to continue.

A NEW MATERIAL FOR PAPER.

The consumptiou of esparto grass by paper-makers in France and England is now very large, and it is yearly increasing. Sir Joseph Hooker and Mr. Ball, in their recently published journal of a "Tour in Morocco," tell us they saw immense bales of this grass being shipped from the port of Mogador, and "that it is there said that the greater part of what reaches England from Morocco is used in the paper-mills that supply the *Times* newspaper." The great value of this grass as a paper-making material lies in the tenacity of its fibre, and the comparatively minute quantity of silica in its composition. In these respects it would appear that we have in all wet, healthy places, moors, aud damp woods throughout Great Britaiu and Ireland, and extending

over all Europe and into Russian Asia, wherever suitable places for its growth are to be found, a similar material in the grass long known as the purple molinia (*Molinia cœrulea*). It is a rather coarse, stiff, perennial grass, often growing to a height of 3 ft.; the leaves chiefly form tufts and start from the base of the plant; the flowering stalk is of a greenish or purple hue. It is found over all the moorlands of Scotland and in all the boggy pastures of Ireland, and has been considered of little, if any, agricultural value; it is gradually, by cultivation, being destroyed. From an analysis of hay made from this grass by Dr. Cameron, it would appear to contain an unprecedently small amount of ash—only 0·85 parts out of 100 parts of hay (dry weight)—and a scarcely appreciable amount of silica. In 100 parts of the ash only 0·55 of silica was found. Dr. Cameron does not suggest this grass as being of value as a paper-making material, but he calls the attention of farmers to the fact that it is well worth saving as a food product, as its composition indicates a high degree of nutritive value; indeed, it appears to be quite as rich as meadow hay in all its common ingredients except digestible non-nitrogenous matters. Its analysis, however, indicates its qualities as a paper-making material, as which it would have a higher commercial value than as an article of food; and, in a communication to *Nature*, Mr. Christie, of Edinburgh, states that he sent a small quantity of the grass to be operated on by Mr. T. Routledge, of Sunderland, who, after experiment, came to the conclusion that if dried properly, and put up carefully in bundles, free from weeds and dirt, its value would be probably equal to esparto grass—£5 per ton dry. It is to be hoped that some effort may be used to have an extended trial for paper-making of this plant. It flowers in the late summer or early autumn, when in this country some hands could be readily spared from other work to collect it. It should cost little over the mere expense of gathering, as the ground in which it flourishes, as a rule, will pay but a minimum of rent.—*Times*.

NOTES ON BOOKS.

The Principles of Light and Colour. By E. D. Babbitt. 1878. New York: Babbitt and Co. London: Trübner.

Mr. Babbitt has published a large book of over 550 closely-printed pages, in which he founds on colours a whole system of philosophy. He has "chromo-chemistry," "chromo-therapeutics, or chromopathy," "chromo-dynamics," and lastly, "chromo-mentalism." Apparently to show his reliance on his own theories, he has printed his volume on paper of what he terms "a diluted sky-blue tint."

Science for All. Vol. I. Cassell, Petter and Galpin, London.

The first volume of Messrs. Cassell's new serial has just appeared. As its name implies, it deals with scientific subjects in a purely popular way. Its contents are of a sufficiently varied sort; there are articles on "The Man in the Moon," "A Piece of Limestone," "Ice, Water, and Steam," "How Plants Feed," "Air and Gas," Why the Wind Blows," "A Pond and what is in it;" these and many similar subjects are treated in a popular way. The book is very fully illustrated throughout with whole page and other engravings.

The Magic Lantern Manual. By W. J. Chadwick. London: F. Warne.

This is a cheap and popular book of instructions for working the magic lantern; it describes the different varieties of lantern in use, from the simple oil lamp up to the most elaborate oxy-hydric apparatus, with its arrangement for dissolving views, microscopic or other scientific work, &c. The numerous appliances for the lantern are also fully described.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

February 5.—"The Best Methods for Improving the Condition of the Blind." By Dr. T. R. Armitage. Sir Charles Trevelyan, Bart., will preside.

February 12.—"The Application of the Bessemer Process to the Reduction of Metallic Sulphides." By John Hollway, Esq.

February 19.—"Turkey and its Resources." By J. L. Haddan, Esq. Lieut.-Gen. Sir A. B. Kemball, K.C.S.I., C.B., R.A., will preside.

February 26.—"Indian Pottery at the Paris Exhibition." By George Birdwood, Esq., M.D., C.S.I.

March 5.—"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By Joseph J. Pope, Esq., M.R.C.S., L.S.A.

March 12.—"The Compensation of Time-keepers." By Edward Rigg, Esq., M.A.

March 19.—"Economical Gardens for Londoners." By W. Mattieu Williams, Esq., F.R.A.S., F.C.S.

March 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor Barff, M.A.

Chemical Section.

Thursday Evenings, at Eight o'clock.

February 13.—"Noxious Vapours, with Special Reference to the Report of the Late Commission." By A. G. Phillip, Esq., F.C.S., Assoc. Royal School of Mines.

March 13.—"The Injurious Effects of the Air of Large Towns on Animal and Vegetable Life, and on Methods Proposed for Securing Salubrious Air." By W. Thomson, Esq., F.R.S.E.

Indian Section.

Friday Evenings, at Eight o'clock.

January 31.—"Quest and Early European Settlement of India." By George Birdwood, Esq., M.D., C.S.I. Andrew Cassels, Esq., Member of the India Council, will preside.

African Section.

Tuesday Evenings, at Eight o'clock.

February 4.—The Opening of the District to the North of Lake Nyassa, with Notes of a Recent Expedition through that Country." By H. B. Cotterell, Esq. Colonel Harley, C.B., will preside.

March 18.—"Some Remarks upon an Old Map of Africa contained in Janson's Atlas, published at Paris in 1612." Communicated and exhibited by R. Ward, Esq.

April 1.—"The Contact of Civilisation and Barbarism in Africa, past and present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

CANTOR LECTURES.

The Second Course will be by Dr. W. H. CORFIELD, M.A., on "Dwelling-houses: their Sanitary Construction and Arrangements." It will consist of Six Lectures, to be given on the following dates :—

LECTURE I.—FEBRUARY 17.

Situation and Structure of House.—Drainage of soil, foundations, walls, roof, rain-water pipes, &c.

LECTURE II.—FEBRUARY 24.

Ventilation, Warming, and Lighting.—Size of rooms, overcrowding, ventilators, stoves, lights, &c.

LECTURE III.—MARCH 3.

Water Supply.—Sources, systems of service, cisterns, pipes, filters, &c.

LECTURE IV.—MARCH 10.

Removal of Refuse Matters.—Dust, kitchen refuse, earth-closets, &c. Conservancy and water-carriage systems compared.

LECTURE V.—MARCH 17.

Sewerage.—Main sewers and house branches, traps, ventilation, &c.

LECTURE VI.—MARCH 24.

Water-closets, Sinks, and Baths.—Arrangements of pipes, traps, &c.

N.B.—The Course will be illustrated by specimens and models from the Parkes Museum of Hygiene.

The Third Course will be by Mr. W. H. PREECE, on "Recent Advances on Telegraphy." It will consist of Five Lectures, to be given on the following dates:—

April 21, 28, May 5, 12, 19.

ADDITIONAL LECTURES.

Monday Evenings, at Eight o'clock. "Some Further Researches in Putrefactive Changes." By Dr. B. W. RICHARDSON, M.A., LL.D., F.R.S., in continuation and completion of his course of Cantor Lectures given last Session.

LECTURE I.—FEBRUARY 3, 1879.

LECTURE II.—FEBRUARY 10, 1879.

The regulations as to admission to these Lectures are the same as for the Cantor Lectures.

Members can admit TWO friends to each of the Ordinary and Sectional Meetings, and ONE friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

MON......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Additional Lectures.) Dr. B. W. Richardson, "Some Further Researches in Putrefactive Changes." (Lecture I.)
Farmers' Club, Inns of Court Hotel, Holborn, W.C., 5½ p.m. Mr. James Howard, "Club Houses for Villages."
Royal Institution, Albemarle-street, W., 2 p.m. General Monthly Meeting.
Society of Engineers, 6, Westminster-chambers, 7½ p.m. Inaugural Address by the President (Mr. Robert Paulson Spice), and presentation of the premiums awarded for papers read during the year.
Royal United Service Institution, Whitehall-yard, 8½ p.m. Major T. Frazer, R.E., "Personal Equipment of Officers on Active Service."
Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. 1. Adjourned discussion on Mr. Hedley's two Papers will be resumed. And, time permitting, 2. Mr. H. J. Castle, sen., "Contributive Value."
Medical, 11, Chandos-street, W., 8.30 p.m.
Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. Mr. J. E. Howard, "The Torquay Caves."
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. R. H. Scott, "The Birth, Life, and Death of a Storm."
Social Science Association, 1, Adam-street, Adelphi, W.C., 8 p.m. Adjourned discussion on Mr. Harold Brown's Paper, "Defects of Joint Stock Banks, and Suggestions for their Remedy."

TUES....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (African Section). Mr. H. B. Cotterell, "The Opening of the District to the North of Lake Nyassa, with Notes of a Recent Expedition through that Country."
English Cart Horse Society (at the HOUSE OF THE SOCIETY OF ARTS), 2 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture IV.
Civil Engineers, 25, Great George-street, Westminster, S.W. 1. Mr. E. Dobson, "The Geelong Water Supply." 2. Mr. J. Brady, "The Sandhurst Water Supply."
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.
Biblical Archæology, 33, Bloomsbury-street, W.C., 8½ p.m.
Zoological, 11, Hanover-square, W., 4 p.m. 1. Prof, A. H. Garrod, "Notes on Points in the Anatomy of the Hoatzin (*Opisthocomus cristatus*). 2. Mr. Sclater, "The Breeding of the Argus Pheasant and other *Phasianidæ* in the Society's Gardens." 3. Rev. O. P. Cambridge, "A New Genus and Species of *Salticides*."

WED. ...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Dr. T. R. Amitage, "The Best Method for Improving the Condition of the Blind."
Metropolitan Association for Befriending Young Servants (at the HOUSE OF THE SOCIETY OF ARTS), 3 p.m.
Geological, Burlington-house, W., 8. p.m. 1. Mr. A. Strahan and Mr. A. O. Walker, "The Occurrence of Pebbles with Upper-Ludlow Fossils in the Lower Carboniferous Conglomerates of North Wales." 2. Prof. V. G. Bonney and Mr. F. T. S. Houghton, "The Metamorphic Series between Caernarvon and Port Dinorwic." 3. Prof. T. G. Bonney, "The Quartz-felsite and Associated Rocks at the base of the Cambrian Series in North-Western Caernarvonshire." 4. Dr. Henry Hicks, with an Appendix by Mr. T. Davies, "A New Group of Pre-Cambrian Rocks (the Arvonian) in Pembrokeshire." 5. Dr. Henry Hicks, with an Appendix by Prof. T. G. Bonney, "Pre-Cambrian (Dimetian, Arvonian, and Pebidian) Rocks of Caernarvonshire."
Entomological, 11, Chandos-street, W., 7 p.m.
Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.
Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Sir Lewis Jarvis, "Myddleton Towers." 2. Dr. Harker, "Pre-historic Remains at Morecombe." 3. Rev. C. Collier, "Roman Villa at Itchen Abbas."
Obstetrical, 53, Berners-street, Oxford-street, W., 8 p.m.

THUR....Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W., 8 p.m. 1. Sir John Lubbock, "Anatomy of Ants." 2. R. Irwin Lynch, "Bull's Thorn Acacia (*A. Sphaerocephala*)." 3. Sir John Lubbock, "Habits of Ants, Bees, and Wasps." 4. Dr. J. Gwyn Jeffreys, "Position of the Genus *Seguenzia* among the Gastropoda." 5. Dr. Henry Trimen, "Note on the Genus *Ovdneya*."
Chemical, Burlington-house, W., 8 p.m. Discussion on Dr. Tidy's Paper, "The Processes for Determining the Organic Purity of Potable Waters."
London Institution, Finsbury-circus, E.C., 7 p.m. Prof. W. Boyd Dawkins, "Britain in the Later Stone Age."
South London Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. H. Gordon, "Electric Induction." (Lecture IV.)
Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.
Royal Society Club, Willis's-rooms, St. James's, S.W., 6 p.m.
Archæological Institution, 16, New Burlington-street, W., 4 p.m.

FRI.......Royal United Service Institution, Whitehall-yard, 3 p.m. Mr. W. Hepworth Dixon, "Cyprus."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Rev. H. R. Haweis, "Bells."
Geologists' Association, University College, W.C., 7½ p.m. Annual Meeting.
Philological, University College, W.C., 8 p.m. Mr. Russell Martineau, "The Rhœto-Romanic Dialect."
National Indian Association, Langham-hall, 43, Great Portland-street, W., 8 p.m. Annual Meeting. Mr. V. K. Dhairyavan, "Musical Teaching for Girls' Schools in India."

SAT. ...Physical, Science Schools, South Kensington, S.W., 3 p.m. Annual Meeting.
Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Mr. Reginald W. Macan, "Lessing." (Lecture I.)

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FRIDAY, FEBRUARY 7, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

AFRICAN SECTION, CANTOR LECTURES, &c.

In consequence of the length of the report of the meeting of the Indian Section on January 31st, it has been found necessary to postpone the publication of the reports of the meeting of the African Section, the Cantor Lecture, and the Additional Lecture.

ADDITIONAL LECTURES.

The special subject of the last lecture of the course on "Putrefactive Changes," by Dr. B. W. Richardson, F.R.S., will be "The Preservation of Animal Substances, and the Comparative Value of Animal and Vegetable Foods."

FOOD COMMITTEE.

This Committee met on Monday, the 3rd inst. Present—Lord Alfred Churchill, in the chair; Sir Antonio Brady; Mr. B. Francis Cobb; Dr. B. W. Richardson, F.R.S.; Mr. E. B. Savile; Mr. S. B. Simon; Mr. E. C. Tufnell; and Mr. J. A. Youl, C.M.G. The Committee witnessed the opening of a case containing specimens of meat preserved by Dr. Richardson with various antiseptic gases, which had been sent to the West Indies and back. The condition of the specimens formed the subject of Dr. Richardson's lecture delivered on the evening of the same day. The Committee also had before them some specimens of coffee-leaf tea, brought from Ceylon by Mr. John Hughes, and manufactured by Mr. H. Cottam, of Ceylon. The tea was apparently well made, but unfortunately the specimen was musty, and no opinion could, therefore, be formed upon its merits. The Committee also tried some extract of coffee, submitted by Messrs. Walker and McLetchie. The general opinion of the Committee was favourable, the aroma being satisfactorily preserved.

CHEMICAL SECTION.

Thursday, January 30th. C. Woodall, M.I.C.E., in the chair.

The Chairman, in introducing Dr. Wallace, said the interest attaching to the lecture was to a great extent due to the experiments lately made with the electric light, and he was very glad they were to have a lecture on the subject of gas illumination, believing it would open up some very important questions as to the economical use of gas. There had been a large amount of waste in the past, and great credit was due to the gentlemen who had devoted so much attention to improving the burners so as to get the maximum amount of light. In London alone half a million of money might be saved if the improved burners were to be universally adopted, and for this reason he was glad that a paper upon the subject was to be read.

The paper read was—

GAS ILLUMINATION.

By Dr. William Wallace, F.R.S.E.

It is impossible to discuss the subject of gas illumination at the present time without referring to the electric light, which many authorities affirm is destined to be the light of the future. If this is so, it might naturally be inferred, by those who have only a slight knowledge of the subject, that it is only wasting energy to devote time and study to the improvement of gas lighting, since it must soon be superseded by the more brilliant light obtained from electricity. I have given this matter some attention, and I must say that I have no fear that gas interests will suffer in consequence of the introduction of the electric light for many, many years, if at all. The mere fact that light can be obtained by passing a powerful current of voltaic electricity between carbon points dates back to a time when gas lighting itself was only in its infancy; and it is now nearly 30 years since the apparatus was so far perfected that the distance between the carbon points was worked automatically; and the improvements recently introduced, if we except the Jablochkoff candle, and the imperfect arc formed in the Werderman arrangement, have been directed more to the effective production of electricity by mechanical power than to the light itself. Turning over an old periodical a few days since, I came upon a paragraph which I read with some interest, in which it stated that a French *savan* had discovered a plan by which the unsteadiness of the electric light was removed. The date of this announcement is 1853—a quarter of a century since—and even now we are scarcely in a position to say that the unsteadiness of the light has been overcome. The fact is, that we have still a long period of experiment and study before us in regard to lighting by electricity, and although the march of improvement in science is now extremely rapid, I scarcely hope to live long enough to see electricity take the place of gas in the lighting of ordinary dwelling-houses. But even if I am in error in supposing that the enormous difficulties will not immediately be overcome, there is still little, if any, cause for alarm on the part of holders of gas stocks, since even at the worst gas is certain to be used side by side with electricity as long as coal can be got to produce it. The fears entertained recently by shareholders of gas companies remind

me of the beginning of railway engineering, when it was asserted that if railways were allowed to be made there would no longer be any use for horses, and the valuable breeds of the animal in this country would be allowed to die out. We all know that the result was entirely the other way; the railways increased the demand for horses, and they became more valuable and more numerous than ever. Then, again, it was supposed that when gas was used for the lighting of towns the manufacture of candles would cease, but what is the fact; more candles are made now than ever there were before, and, what is very much to the purpose in connection with my subject to-night, the greatest improvements in the manufacture of candles were made after the gas manufacture was fairly established. Even within my own recollection candles were burned which required constant snuffing, and so late as 30 years ago artistic designs for snuffers and snuffer-trays were published in art journals. If electricity supplants gas for public lighting, as I believe it may to some extent, it is all the more necessary that we should strive to get more light out of gas, either by improvements in the mode of manufacture, or by better means of burning it, or both, and I am very sanguine that gas lighting during the next 30 years will be developed to an extent of which we can at present form no adequate idea. We have seen some improvements in gas lighting already. What was at one time 12-candle gas, tested by the primitive Argand, became 14-candle gas with the Sugg-Letheby burner, and 16-candle gas with Sugg's London Argand; and all this without sensibly changing the quality of the gas, and, consequently, without conferring any benefit on the public. A real and substantial improvement in gas lighting would be one which would enable the public to get, in ordinary domestic life, something approaching to the illuminating power declared as the result of the official tests, and the object of this paper is to show what has been done up to the present time in this direction. Before passing on to my subject, however, I wish to make just one remark. If the production of gas is sensibly decreased, the value of the by-products will proportionately rise, the demand for benzole, anthracen, tar oils, pitch, and ammonia will continue; and, if the quantity produced becomes less, the value of these important articles will undoubtedly increase.

Coal gas is a cheap source of light, the only real competitor in this respect being paraffin oil. The following Table gives the comparative values, based on what may be accepted as average prices, although some of them may not be exactly correct at the present time:—

Cannel gas, 30 candles, at	4s. 2d. per 1,000 c. ft.	1
Common gas, 16 candles .	3s. ,,	$1\frac{1}{3}$
Paraffin oil	1s. 6d. per gallon	$1\frac{3}{4}$
Colza oil in moderator lamps	4s. 6d. ,, ...	7
Stearine candles	10d. per pound	27
Tallow ,, ...	8d. ,, ...	29
Paraffin ,, ...	1s. 6d. ,, ...	31
Sperm ,, ...	1s. 6d. ,, ...	36
Wax ,, ...	2s. 6d. ,, ...	72

In these comparisons, it is but fair to say, the gas is calculated as giving the light obtained when burned in the best known manner, as in the official tests of the gas examiners of the towns where the respective qualities of gas are made.

It will be well to indicate, in a few words, the principle involved in the testing of various gas flames and other sources of light. If a flame of any kind is held at any distance, say a yard from a screen, in which an opening is made one foot square, and a second screen is placed at the distance of two yards, there will be thrown upon the latter a square figure, which on examination will be found to measure exactly 2 feet, and which has therefore an area of 4 square feet. If the second screen is moved to 3 yards, the illuminated portion will measure 3 feet square, representing an area of 9 square feet; at 4 yards it will measure 4 feet, giving an area of 16 square feet. We thus see that the space covered by the light increases in proportion to the square of the distance, while the intensity of light decreases in a corresponding degree. To put the matter more clearly to those who have not studied the subject—a flame at a given distance, say a yard, illuminates a given space, say a foot square, but at four times the distance the illuminating effect is diffused over 16 times the area, or 16 square feet, consequently any single square foot at this distance gets only one-sixteenth part of the whole quantity.

I do not propose to enter into any details regarding photometers, all of which are based upon this principle, but I may explain the mode of testing by a simple illustration. I have a space of 100 inches, with a candle at one end, and a gas flame which I wish to test at the other. I have a greased disc moving freely between the two, and by a little practice I can place it in a position in which the two sides are equally illuminated. I now measure the distance between the candle and the disc, and find it to be 20 inches, while that between the gas flame and the disc is 80 inches; the square of 20 is 400, and of 80 6,400, and the one divided by the other gives 16 candles as the illuminating power of the gas flame. In practice the photometer is divided so as to give the illuminating power by direct observation, and many details require to be minutely attended to in order to obtain reliable results.

We are in the habit of talking of certain qualities of gas—16 candles in London, 15 in Birmingham, 14 in Newcastle, 26 in Glasgow, 30 in Edinburgh, but these are not the values of the gas as burned in our houses, warehouses, and shops, but as burned in the manner calculated to give the highest illuminating power. These figures show the possibility of gas illumination, and represent the goal towards which we should strive. I freely admit that it is impracticable, not to say impossible, to obtain in the every-day practice of common life results as good as those got by means of appliances the most perfect for developing the full photogenic value of the gas, but still a great deal may be done to decrease the reckless waste of light that is constantly going on. I have no hesitation in saying that from 12 to 14 candle power might be obtained in every-day life from what is called 16-candle gas. We stand in a similar position with regard to various forces employed for practical purposes. The engineer calculates the power that should be obtained by the falling of a given weight of water through a given space, but the practical result obtained in

a water-wheel always falls far short of the theoretical quantity. In like manner, the force obtained by the combustion of one pound of coal in the boiler of a steam-engine is greatly less than the calculated figure. Still, mechanicians struggle on to obtain better results, and we are constantly improving. Some of the most recent forms of reaction engines show an immense improvement on the water wheels formerly in use, while, in regard to steam power, we have, in the performance of the best descriptions of compound engines, an approach to theory which was formerly deemed impossible of attainment. Such improvements represent so much money saved to the country; and it is equally the case with gas, but with this addition, that a decreased consumption, with the same amount of light, would give increased healthfulness to our dwellings, where the products of the combustion of gas constitute an evil of no small magnitude. It has been said that the man who causes two blades of grass to grow where only one grew before is a benefactor to his country, and some honour is due also to him who enables us, by improvements in the steam-engine, to get out of one pound of coal the power which formerly required the combustion of two pounds, or who teaches us how to obtain from one cubic foot of gas the illuminating value for which two feet had previously been expended.

When a porcelain slab is brought over a gas flame a deposit of carbon occurs: the particles exist in the flame, and the contact of the cold slab causes their instant deposition. A similar effect is produced by a current of cold air impinging upon a flame, a portion of which is thus cooled down below the temperature necessary for the combustion of the carbon, and the flame thus exposed to the draught smokes, that is, the finely divided particles of carbon pass into the air unconsumed. In ordinary circumstances, the carbon is consumed in the upper portion of the flame, and if the jet be a good one, and the pressure of gas not too low, no smoke is produced. In the Bunsen burner the gas is mixed with air sufficient to prevent the separation of the carbon, and hence we have a flame which is valueless as a source of light, but convenient for the application of heat. The solid particles of carbon in an ordinary gas flame result from the decomposition of the olefines and other compounds rich in carbon, which are readily decomposed by the action of heat. The same thing occurs if coal gas be passed through a glass tube heated to redness; in this case a deposit of carbon in the interior of the tube occurs at the point where the heat is applied. In gas works a similar effect is produced by the heating of the impure gas in the retorts, in which a deposit of carbon, sometimes three or four inches in thickness, is formed. This carbon was formerly used for the rods or pencils employed in producing the electric light. The presence of the particles of carbon in a flame renders it opaque, and the degree of opacity varies with the illuminating power. At the bottom of a flat flame, where the oxygen is in excess, the transparency is such that a printed paper may be read through it as if no obstruction intervened, but the upper part almost entirely conceals the printing. The intensity of light depends partly upon the quantity of the carbon particles, and partly upon the heat of the flame by which the carbon is brought up to a greater or less degree of incandescence. Professor Frankland has shown that the light is not entirely due to the separated carbon, and that certain chemical compounds—gases or vapours—from which carbon does not separate by the action of heat, are capable, under some conditions, of giving luminous flames when burned in air. For all practical purposes, however, the original proposition of Davy may be accepted, that the light is radiated from highly heated particles of solid carbon. When air is supplied in excess to a flame, as when the gas escapes through a fine jet at a high pressure, there is little separated carbon, the flame is transparent or nearly so, and there is very little luminosity. On the other hand, when the flame is large and sluggish, and the air in contact with it is insufficient, the solid carbon is in excess, and a part of it escapes unburnt, giving rise to a smoky flame, in which also the luminosity may be low. What we have to strive after in order to obtain the greatest possible "duty," as mechanical engineers would call it, from gas, is to burn it so as to have the flame as hot as possible, and as near the smoking point as is consistent with the perfect consumption of the carbon in the upper part of the flame. In few words, the whole science of gas lighting is the obtaining a bright flame without smoke. It was at one time accepted as an axiom that economy in gas lighting could only be obtained by the use of large burners, and that in small jets the contact of air was necessarily so complete that only a feeble light could be obtained. But this is only partially true; more precise and extended experiments have shown that the luminosity depends not so much upon the quantity of gas as upon the conditions under which it is burned. In the case of flat-flame burners, the most essential element is pressure, a high initial velocity giving a low illuminating power, and *vice versa*. I may give a few illustrations from my own experiments—the gas used being of 26 candles illuminating power for five cubic feet per hour. In all the instances I am about to quote Bray's ordinary union jets were used. The gas gave the most unfavourable result when the smallest burner of the series, No. 0, was used under comparatively high pressure—$1\frac{1}{2}$ inches—two cubic feet per hour gave an illuminating effect of 3·21 candles, or calculated to the standard of five cubic feet per hour, eight candles. The best result, on the other hand, was obtained with a No. 8 burner at one inch pressure, when 7·1 cubic feet gave an illuminating effect of 40·63 candles, or for 5 cubic feet, 28·6 candles. Here is a striking contrast, the same gas giving at one time 8-candle power for five feet an hour, at another 28·6, the jets being respectively the smallest and the largest of the series of nine. But let us now take the same quantity of gas under varied conditions of pressure, and we shall see even here very marked differences. Three cubic feet burned at half-inch pressure, and calculated to five feet per hour, gave 25 candles; at one inch pressure, 19 candles; and at $1\frac{1}{2}$ inch, $12\frac{1}{2}$ candles. Here we have the effect simply of pressure, which, in the case of flat-flame burners, is of paramount importance. When common gas is used, the effect of pressure is even more remarkable, the varieties being such that in some cases less than one-fourth

of the possible amount of light producible is really obtained.

A remarkable effect is obtained with a mixture of cannel gas with about twice its bulk of air. At a low pressure, in an Argand jet with large holes, it gives a fairly luminous flame, while at a high pressure (3 or 4 inches), although the quantity of gas consumed is three times as great, the flame is almost totally non-luminous, and has a greenish tint. The gas used somewhat extensively in the United States, made by saturating air with petroleum spirit, requires to be burned at a pressure not exceeding 0·1 of an inch, which can be obtained only with an Argand with very large holes, or a bat's-wing of peculiar construction, called the American regulating bat's-wing. At ordinary pressures, such as are used for coal gas, there is scarcely any light, and the flame keeps about a ¼ inch or more above the burner.

It is not only on the score of economy that it is desirable to burn gas in such a manner as to afford the greatest possible amount of light. The burning of a moderate-sized jet of gas produces as much carbonic anhydride as the breathing of two grown-up men; and as, in an ordinary apartment, we have usually from three to six of these, the air becomes vitiated with remarkable rapidity. It is therefore desirable, in relation to health, to obtain the illumination we require with the least possible expenditure of gas. The sulphur in gas is a very serious drawback to its use. In burning, it is no doubt formed chiefly, if not entirely, into sulphurous anhydride; but it is soon converted into sulphuric acid, which attacks with avidity all the more readily destructible articles in the apartment. So far back as 40 years since, the effects of the sulphuric acid arising from the combustion of gas upon the binding of books and many articles of furniture were noted; and recent experiments have shown that leather, paper, &c., in ill-ventilated apartments, exposed to the emanations from burning gas for a series of years, contain large quantities of sulphuric acid.

There are several qualities of gas in use in this country. The best may be described as Scotch cannel gas, as it is made only in Scotland, where the illuminating power varies from 24 to 30 candles for 5 cubic feet per hour consumed in a union or fish-tail jet: the average may be fairly stated as 26 candles. In London a cannel gas is used in small proportion, the illuminating power of which is about 23 candles; and in Liverpool, Manchester, Carlisle, and probably some other towns, an intermediate gas is manufactured, the illuminating power of which is about 20 candles. The common gas in London, and most other English and Irish towns, has an illuminating power of 14 to 16 candles. In the case of cannel gas, the standard is found by testing the gas by a union jet consuming 5 cubic feet, at a pressure of 0·5 of an inch, while the common gas is tested by Sugg's "London" Argand, consuming 5 cubic feet per hour, at a pressure of about 0·05 of an inch.

The burners at present in use may be divided into the four following classes:—1. Cockspur, or rat-tail. 2. Union, or fish-tail. 3. Bat's-wing. 4. Argand. Of each of these there are a number of modifications.

The cockspur, or rat-tail burner, is the simplest possible form of gas-jet, and it was at one time the only one used for burning gas. It may be made by simply drawing out a piece of glass tube and breaking off the point so as to leave an orifice having a diameter of 1 millimètre or less; but it is usually constructed of cast iron, which is drilled as wide as possible from the bottom, leaving only a thin shell, which is then bored with a fine drill. Two sizes of these were tested, No. 1 having an orifice of about 0·6, and No. 2 of about 0·75 millimètre. These jets are used in Glasgow for lighting common stairs, and the larger sizes were formerly employed for street lamps, but are now discarded in favour of union jets. The following are the results with 26-candle gas:—

No. of Burner.	Pressure in Inches.	Length of Flame in Inches.	Gas per hour.	Illuminating Power in Standard Candles.	Illuminating Power of Five Cubic Feet per Hour in Candles.
1	0·5	2	0·45	0·89	9·9
1	1·0	3½	0·60	1·69	14·1
1	1·5	4⅜	0·90	2·40	13·3
2	0·5	3⅞	0·80	2·49	15·6
2	1·0	5⅞	1·13	3·55	15·7
2	1·5	7½	1·45	4·53	15·6

These figures show that, even with the larger jet, no more than 60 per cent. of the real value of the gas can be obtained. I have tried various modified forms of the jet, some having "adamas" tips, and contracted at the bottom, or otherwise obstructed so as to diminish the pressure at the point of ignition, but they did not show any marked superiority over those referred to above.

When two rat-tail jets are held at a right angle to one another, the lights coalesce and form a flat sheet of flame. When this discovery was first made, two burners were fitted up in this way, but soon a single burner was contrived which combined the two, and hence was called a "union" jet; it is also known as a fish-tail, from the resemblance of the flame to the tail of a fish. It is a short cylindrical tube with a flat top, in which the two orifices are drilled at about 90 degrees to one another, and meeting in the centre. The union jet is much improved by substituting for the metal top porcelain or stoneware, the principal advantage gained being that the orifices remain clean and constant in size, while those of iron gradually rust up and require to be frequently cleaned in order to give a satisfactory light, and are consequently enlarged. Some fish-tail burners are made entirely of a kind of stoneware or of steatite, but these are troublesome to remove when they get broken. The best form of burner is that with a brass body and porcelain top. Such burners are made by Leoni of London, Bray of Leeds, and other makers, but usually with some means of reducing the pressure. The fish-tail burner is not suited for burning at a high pressure, under which the two flames refuse to spread out into a flat sheet, but form an irregular flame, at the same time emitting a most disagreeable hissing or blowing sound. This effect may also result from other causes, such as a sharp bend in the gas-supply tube, a speck of dust in one of the orifices of the burner, or, in fact, anything that disturbs

the even and quiet flow of the gas. One singular example of this is the following:—If a union jet is burning five cubic feet of gas at 0·5 inch pressure, and a portion of gas is led away by means of a tube inserted a few inches below the flame, although diminished in volume, it immediately begins to blow.

In testing flat flames, the custom has invariably been to present the flat side to the disc of the photometer; but, although the results so obtained are satisfactory in comparing one flat flame with another, they cannot fairly be compared with rat-tail or Argand flames, which give an equal light all round. The edge of a flat flame gives considerably less light than the side, but the difference between the two depends very much upon the richness of the gas, or, in other words, the opacity of the flame. The following example may be given:—A union jet, consuming five cubic feet of cannel gas, at 0·5-inch pressure, gave a light of 27 candles when tested in the ordinary manner with the flat side towards the photometer disc; but the edge gave only 23 candles, and when rotated, so as to give the flame in every position, the average result was as nearly as possible 26 candles, showing that the ordinary test gave one candle too much, or nearly 4 per cent. In the case of paraffin flat-flame lamps, the difference between the front of the flame and the average all round varies from 4 to 10 per cent. In the latter case, the flame is intensely opaque, and of a deep yellow colour. All the figures given in this paper refer to the flat side of the flame, and this must be borne in mind in comparing flat with round flames.

The following Table gives the results obtained with Bray's union jets, without obstruction to retard the flow of gas and reduce its pressure. Gas by ordinary test, 26 candles:—

No. of Burner.	At 0·5 Inch Pressure.			At 1·0 Inch Pressure.			At 1·5 Inch Pressure.		
	Gas per hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.
0	1·15	1·96	8·52	1·55	2·35	7·60	1·80	2·45	6·80
1	1·45	3·77	13·00	2·15	5·28	12·28	2·85	5·47	9·60
2	1·70	4·85	14·27	2·50	6·74	13·48	3·10	7·62	12·30
3	2·35	8·98	19·10	3·40	11·73	17·25	4·30	13·67	15·90
4	2·85	11·97	21·00	4·05	15·44	19·06	5·00	16·62	16·62
5	3·25	13·84	21·30	4·50	18·78	20·87	5·55	21·90	19·73
6	4·10	19·60	23·90	5·70	25·60	22·46	—	Gas blows	—
7	4·75	24·76	26·00	—	Gas blows	—	—	,,	—
8	5·00	26·00	26·00	—	,,	—	—	,,	—

This Table gives instructive information as to the effects of mass or quantity of gas and of pressure. As regards mass, we see that at the same pressure the light afforded by 5 cubic feet of gas per hour varies from 8½ to 26 candles, according to the quantity burned, the lowest result being obtained with about 1 cubic foot per hour, and the highest with 5 cubic feet. This last result—*i.e.*, 26 candles for 5 cubic feet of gas per hour, burned in a union jet at 0·5-inch pressure, is taken as the standard of comparison in all the experiments on cannel gas. The ratio of illuminating power to quantity is nearly the same at higher pressures, and there is no difficulty in deducing the general law that the value in illuminating effect per cubic foot of gas increases with the mass of the flame.

The effects of pressure are not less striking, and might have been more so had the gas been tested at lower pressures than 0·5-inch and higher than 1·5-inch. The results obtained with a jet consuming 5 cubic feet per hour gave 26 candles at the low pressure, and only 16·6 at 1·5 inch, showing a loss of lighting power amounting to about 36 per cent.; 3 feet per hour, calculated to 5 feet, gave at the low pressure 21 candles, at the high pressure 12·3 candles; the burner being a No. 4 in the one case, and a No. 2 in the other. The medium pressure gave results intermediate between these. At the higher pressures some of the larger-sized burners became useless, as already explained.

As, in practice, it is found impossible to distribute gas at a pressure of less than 12 or 15-10ths of an inch of water, various contrivances for breaking the force of the gas have been invented. Among union jets of this kind, the simplest, perhaps, is that of Leoni, consisting of a brass and an iron tube, which fit into one another, and between which a thin film of cotton wool is placed. This is a very good burner, but it cannot be depended upon for delivering exact quantities of gas. Bray has constructed a very good burner, similar to those already mentioned, but having a double ply of cotton cloth stretched across a metal ring placed in the tube, in order to relieve the pressure. The same manufacturer has more recently invented another burner, in which the reduction of pressure is attained by passing the gas through an orifice in a porcelain plate cemented into the lower part of the burner. He calls these "Special" burners, and they are of two kinds—one intended for general use, and the other for street lamps, in which the orifices are somewhat smaller, and in which, consequently, the pressure is further reduced. Morley's patent burner is of brass and vase-shaped, with a porcelain top, and at the bottom one or two small orifices in the metal for admitting the gas. Williamson's jet is similar in principle, but more complicated in construction. Da Costa's burner consists of a hollow vase stuffed with iron turnings, into which an ordinary iron union jet is screwed.

There are others, but all have the same object in view, and the simpler and cheaper burners, such as Leoni's and Bray's, accomplish it as successfully as those of more complicated construction, and these have, therefore, been selected for a series of comparative trials, all being made with 26-candle gas. Some of the burners referred to are called regulators, but this is a mere name, for it is obvious that they merely obstruct the flow of gas, the quantity delivered rising as the pressure is increased. In Bray's "Special" burner the two holes forming the "union" jet are placed at an angle of 120°.

In both series of the "Special" burners, in

Bray's "Regulator" Union Jets for Cannel Gas.

No. of Burner.	At 0·5 Inch Pressure.			At 1·0 Inch Pressure.			At 1·5 Inch Pressure.		
	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.
0	1·00	2·72	13·6	1·50	3·13	10·4	2·00	3·21	8·0
1	1·15	3·75	16·3	1·80	4·30	11·9	2·45	4·40	9·0
2	1·50	5·63	18·7	2·30	7·25	15 8	3 00	7 60	12 6
3	1·80	7·97	22·1	2 75	10·11	18·4	3·55	11·37	16·0
4	2·40	11·26	23·4	3·60	15·21	21·1	4·30	15·32	17·8
5	2.60	12·76	24·5	4·35	20·40	23·4	5·10	22·19	21·7
6	3·15	15·95	25·3	4·95	25·42	25·7	5·80	27·51	23·8
7	3·80	20·07	26·4	6·05	32·75	27·1	..	gas blows	..
8	4·70	24·76	26·3	7·10	40·63	28·6	..	,,	..

Bray's "Special" Union Jets for General Use.

No. of Burner.	At 0·5 Inch Pressure.			At 1·0 Inch Pressure.			At 1·5 Inch Pressure.		
	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.
0	1·44	5·51	19·13	2·16	9·22	21·34	2·59	10·80	20·85
1	1·55	6·11	19·71	2·36	10·33	21·88	2·87	12·00	20·91
2	1·86	7·50	20·16	2·76	12·38	22·43	3·36	14·51	21·59
3	2·10	8·90	21·19	3·10	14·27	23·01	3·75	17·29	23·11
4	2·44	10·94	22·42	3·62	17·69	24·43	4·41	20·83	23·60
5	2·71	13·39	24·70	4·13	21·13	25·58	5·16	26·17	25·36
6	3·12	15·42	24·71	4·76	24·40	25·63	5·71	28·66	25·09
7	3·63	18·43	25·39	5·51	28·65	26·00	6·70	34·33	25·62
8	4·28	22·26	26·00	6·39	34·37	26·89	7·92	40·67	25·67

Bray's "Special" Union Jets for Street Lamps.

No. of Burner.	At 0·5 Inch Pressure.			At 1·5 Inch Pressure.			At 1·0 Inch Pressure.		
	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per Hour.	Illuminating Power.	Illuminating Power. per Five Cubic Feet.
0	1·30	4·85	18·65	1·96	8·22	20·97	2·34	9·70	20·73
1	1·46	6·04	20·68	2·21	9·57	21·65	2·63	11·45	21·77
2	1·73	7·28	21·04	2·56	12·00	23·44	3·01	14·86	24·68
3	2·07	9·36	22·61	3·00	14·64	24·40	3·57	17·63	24·69
4	2·24	10·73	23·95	3·33	16·57	24·88	4·05	20·39	25·17
5	2·68	13·15	24·53	4·08	21·17	25·94	4·85	25·67	26·46
6	2·97	14·77	24·86	4·45	23·73	26·66	5·37	28·87	26·88
7	3·44	17·37	25·25	5·31	28·36	26·61	6·43	34·32	26·69
8	3·84	19·21	25·01	5·92	31·22	26·37	7·23	37·32	25·81

which the pressure is much reduced, the best results are obtained at 1 inch pressure, while, at ·5 inch, the flames are sluggish, and, in some cases, show a tendency to smoke. This is not the case, however, when common gas is used.

Mr. Holdsworth, of Bradford, has introduced a simple arrangement which he calls a gas-feeder, which has been adopted rather extensively in the manufacturing towns of Yorkshire. It is simply a little wedge-shaped piece of lead pierced in the centre with a hole, the area of which is less than that of the holes in the burner, and this is fixed in the gas pipe several inches from the burner. Several sizes are made, to suit varying circumstances of local pressure, as well as different sizes of burners, and if fitted up by an intelligent workman, they accomplish the end in view very successfully.

Many years ago, Mr. Scholl, of London, adopted the system of placing a small piece of platinum between the two orifices of the union jet, the result being that the initial velocity with which the gas escapes is spent by striking against this plate, and the gas ascends in a somewhat sluggish flame, which, in the case of cannel gas, has a tendency to smoke, and is easily blown about by currents of air. This is the case also with all union jet flames burned at very low pressures, and, practically, a jet of this kind cannot be burned much below 3-10ths or 4-10ths for small sizes, and 5-10ths for large sizes consuming four or five cubic feet per hour. Scholl's "perfecter," as he has called it, has been used extensively in London and other towns for common gas, but it is not suitable for the richer gas used in Scottish towns.

A flame formed by a jet of gas issuing with considerable velocity possesses a certain degree of stiffness, and resists, to some extent, the influence of currents of air. This is particularly necessary in the case of cannel gas, since, whenever the flame is much deflected by air currents, a portion of the carbon arising from the heating of the richer hydrocarbons (*e.g.*, olefines, benzole, &c.) passes off unconsumed, and a smoky flame is the result. In practice, it is necessary to sacrifice a certain proportion of the possible illuminating value, in order to give the flame sufficient stiffness to resist currents of air.

Next to the union jet, the "bat's-wing" is that most commonly used for burning gas. It is simply a little tube closed at one end, in which a straight slit is cut, varying in breadth from about 2-10ths to one millimètre. It is made of cast-iron, brass, porcelain, or steatite; the best form being that having a brass body and steatite top. The flame of the bat's-wing is wider and shorter than that of the union jet, and, in order to be equally effective, requires to be burned at lower pressures. It is particularly adapted for large flames burning from $3\frac{1}{2}$ to 5 cubic feet of gas per hour. With rich cannel gas (25 to 30 candles) it gives results at least equal to the union jet, and with gas of 18 to 22 candles, it is decidedly superior.

The following Table gives the results of tests of a series of steatite bat's-wing burners manufactured in Germany. Gas, 26 candles.

o. of Burner.	At 0·5 Inch Pressure.			At 1·0 Inch Pressure.			At 1·5 Inch Pressure.		
	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Ft.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Ft.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Ft.
2	1·10	4·24	19·27	2·35	9·05	19·25	3·15	11·56	18·35
3	1·45	5·68	19·58	2·65	10·02	18·90	3·55	13·20	18·59
4	1·90	8·76	23·05	3·10	12·71	20·50	4·00	15·41	19·26
5	3·40	16·18	23·80	5·20	24·07	23·14	—	gas blows	—
6	4·05	19·09	23·57	—	gas blows	—	—	,,	—

The considerable loss of light experienced when gas is consumed in bat's-wing burners at any but comparatively low pressure, has given rise to many efforts to combine with the jet an apparatus to reduce the pressure of the gas before it issues from the narrow slit. Various burners having obstructions have been constructed, of which Brönner's is one of the best known. It consists of a somewhat pear-shaped brass body, with a steatite top, similar to those of which the results are given above, and at the bottom a small piece of steatite in which is an oblong slot. There are, for cannel gas, six sizes of bodies, the sizes depending upon the area of the slots, and five sizes of tops; and as these screw into one another, there are 30 possible combinations. In none of these combinations does the pressure of the gas at the point of ignition exceed 0.5 of an inch with an initial pressure of 1·5 inch, while in some it is only 0·2, and in some it is so low that the flame smokes and is useless. The rate of combustion is dependent on three conditions—first, the area of the opening at the bottom; secondly, the area of the slit in the burner; and thirdly, the initial pressure of the gas. The range of combinations enables one to select a burner to suit almost any description of gas or any standard of pressure. The accompanying Table gives the results of tests at 1 inch and 1·5 inch, with 26 candles. The burners are not adapted for lower pressures than 1 inch.

For common gas (*i.e.*, of 14 to 16 candles) a different series of tops is provided, in which the areas are considerably greater than in those made for cannel gas, and in which the pressure is reduced to from 0·1 to 0·3 of an inch. These burners cannot be used with cannel gas, although with common gas they are exceedingly effective, and are much in use, especially in London.

Bronner's Burners for Cannel Gas.

At 1·0 *Inch Pressure.*					*At* 1·5 *Inch Pressure.*				
No. of Burner.	No. of Top.	Cubic Feet per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	No. of Burner.	No. of Top.	Cubic Feet per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.
2	2	1·20	5·07	24·13	2	2	1·40	5·25	18·75
2	3	1·40	6·64	23·71	2	3	1·95	7·37	18·90
2	4	..	Smokes	..	2	4	2·30	10·33	22·46
2	5	..	,,	..	2	5	2·40	11·24	23·42
2	6	..	,,	..	2	6	..	Smokes	..
2½	2	1·40	5·53	19·75	2½	2	1·90	8·30	21·84
2½	3	1·70	8·48	24·94	2½	3	2·30	10·14	22·04
2½	4	2·03	10·33	25·49	2½	4	2·70	12·08	22·37
2½	5	..	Smokes	..	2½	5	2·85	14·29	25·07
2½	6	..	,,	..	2½	6	3·00	15·21	25·35
3	2	1·45	6·27	21·62	3	2	2·00	8·48	21·20
3	3	1·90	8·66	22·89	3	3	2·50	11·34	23·63
3	4	2·13	11·24	26·39	3	4	2·80	14·84	26·50
3	5	..	Smokes	..	3	5	3·15	17·04	27·20
3	6	..	,,	..	3	6	3·25	18·07	27·80
3½	2	1·50	5·81	19·36	3½	2	2·12	8·85	20·87
3½	3	1·95	8·30	21·28	3½	3	2·55	12·63	24·76
3½	4	2·55	12·08	23.68	3½	4	3·00	14·47	26·12
3½	5	2·80	14·38	25·68	3½	5	3·50	18·07	25·81
3½	6	3·00	15·58	25·97	3½	6	3·60	19·45	27·01
4	2	1·60	6·36	19·87	4	2	2·30	9·77	21·24
4	3	2·10	10·69	25·45	4	3	2·90	13·83	23·84
4	4	2·65	13·37	25·23	4	4	3·30	17·06	25·85
4	5	3·45	17·61	25·52	4	5	4·10	21·57	26·30
4	6	3·55	18·07	25·45	4	6	4·20	22·40	26·66
5	2	1·77	7·38	20·85	5	2	2·60	9·68	18·81
5	3	2·30	11·90	25·87	5	3	3·30	13·64	20·67
5	4	3·30	15·40	23·33	5	4	4·00	19·91	24·14
5	5	4·10	20·74	25·29	5	5	5·00	25·36	25·36
5	6	4·30	22·68	26·37	5	6	5·30	27·66	26·10

This Table shows that it is easy, with properly adjusted bat's-wing burners, to obtain, with a consumption of from 3 to 5 cubic feet per hour, at least the full effect of illumination exhibited in the standard mode of testing already referred to; and that, even with a consumption of 2 cubic feet, a very favourable result may be obtained. In no case is the loss of light with bat's-wing burners so great as with badly arranged union jets.

Many other descriptions of improved bat's-wings have been constructed, some of which I have tested. The "Clegg" bat's-wing, manufactured by Sugg, has a steatite top, and a conical brass body closed at the bottom, and with a slit cut in it with a fine saw. The respective sizes of the slits above and below determine the consumption of gas and the pressure at the point of ignition. In Silber's bat's-wing, made by the Silber Light Company,

Clegg and Silber Bat's-wings.

Burner.	At 0·5 Inch Pressure.			At 1·5 Inch Pressure.			At 1·0 Inch Pressure.		
	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet,
Clegg, No. 2	2·00	9·15	22·87	3·40	14·77	21·72	4·45	18·30	20·56
Do. ,, 3	2·90	13·00	22·41	4·45	21·11	23·72	5·70	27·04	23·72
Do. ,, 4	4·20	20·37	24·25	6·45	31·20	24·19	—	Blows	—
Do. ,, 5	4·80	23·92	24·92	—	Blows	—	—	,,	—
Silber A	0·95	3·07	16·16	1·50	6·31	21·03	1·90	10·03	26·40
,, B	1·55	7·34	23·68	2·35	12·07	25·68	3·00	15·04	25·07
,, C	2·20	11·24	25·54	3·30	17·27	26·17	4·25	23·12	27·20

one burner is placed above another, both being of steatite, the slit of the lower one being much smaller than that of the upper, and connected by a vase of brass. Only the three smallest sizes of these are suitable for rich cannel gas, the larger ones being intended for gas of lower quality. The results obtained with 26-candle gas are given in the Table on the preceding page.

Several varieties of regulating bat's-wings have been invented by Sugg, Witthoft, Winsor, and others, the principle of their construction being to check the flow of gas by means of a plug regulated by a screw. At a given pressure in the pipes the burners may be regulated to deliver any desired quantity of gas, and in the experiments on the Winsor and Sugg burners quoted below, they were regulated so as to burn the number of cubic feet per hour corresponding with the numbers marked on the burners. Gas used equal to 26 candles :—

Sugg's "Winsor" Bat's-wing.

No.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.
2	2	9·60	24·00
3	3	15·00	25·00
4	4	19·87	24·84
5	5	25·20	25·20
—	—	—	—

Sugg's Regulating Bat's-wing.

No.	Gas per Hour.	Illuminating Power.	Illuminating Power per Five Cubic Feet.
2	2	9·20	23·00
3	3	15·34	25·56
4	4	19·90	24·88
5	5	24·75	24·75
6	6	28·74	23·95

If two bat's-wing flames are brought together, especially if the slits be narrow, the gas of low quality, and the pressure somewhat high, the illuminating power of the united flame is greatly in excess of the sum of the two tested separately. Upon this principle is constructed a double-slit bat's-wing, the slits being about one millimètre apart, which is used in Manchester and other towns in England, and which is an excellent burner for gas not exceeding 20-candle power, but gives a somewhat smoky flame with gas of high quality.

The only other bat's-wing that requires further to be noticed is the patent regulating bat's-wing used in the United States of America, where it was introduced in 1871, and which is practically the only flat-flame burner capable of burning advantageously the "air gas," made by saturating air with the vapour of petroleum spirit. It consists of a very much elongated iron bat's-wing, with exceedingly narrow slit, surrounded by a brass tube at the distance of about 2 millimètres. Into the space between the two, gas is admitted by a wide orifice (the amount being regulated by a screw), and this gas ascends entirely without pressure, while the force of the gas issuing from the narrow slit spreads it out into a fine soft flame. This burner gives excellent results with gas of all qualities, but its shape is not adapted to the gas-fittings in use in this country, and it has not been used here except for air gas made for private houses.

Argand burners are exclusively used in the photometric testing of common gas, and they are also employed rather extensively for lighting shops and public buildings, but to a limited extent for private houses. They give a higher photometric effect with common gas than any flat-flame burner known; and even with cannel gas, the best descriptions, especially those of Sugg and Silber, give results which approach very near to those obtained when the gas is tested at a comparatively low pressure by large-sized fish-tail or bat's-wing burners.

The original form of Argand was a brass double cylinder with, above, an iron ring perforated with small holes, and below, a "crutch" or forked tube, by which the gas was introduced at opposite sides. A wide and short glass chimney was used, but this was afterwards modified in a variety of ways with a view to making the current of air impinge more directly upon the flame, and so increase the intensity of combustion. The holes being small, the gas escaped at a comparatively high pressure; and the character of the flame, both as to volume, shape, and luminosity, depended partly upon the initial velocity with which the gas escaped from the burner, and partly upon the shape and dimensions of the funnel. The enlargement of the holes, enabling the gas to escape at a moderate pressure, was proposed by the late Dr. Letheby, who was associated with Mr. Sugg, by whom a great many improvements in Argand burners have been introduced. The Letheby burner raised the apparent quality of London gas from 12 to 14 candles, and a further increase of two candles was obtained by Sugg's "London" Argand, now generally accepted as the standard burner for testing gas made from common coal. In this burner the principle is recognised of permitting the gas to escape practically without pressure, the shape and volume of the flame being determined by the narrow funnel and a "cone" of thin metal, which serves to throw the current of air into close contact with the outside of the flame. The upper portion of the burner is of steatite, and, instead of the ordinary "crutch" below, the gas is introduced by three very narrow tubes. A number of sizes of this burner are made, of which details are given below; but the following are the various dimensions of the standard burner used in photometry:—Diameter of steatite top, external, 0·84 inch; internal, 0·47 inch; number of holes, 24; diameter of holes, ·04 inch; chimney, 6 × $1\frac{3}{4}$ inches for gas of 14 candles, and 6 × 2 for gas of 16 candles. The narrow funnel and the cone restrict the quantity of air to very little more than is required to burn the gas, thus avoiding the diminution of light which results from a too rapid combustion of the gas, and the cooling effect of a large volume of air. The pressure of the gas inside the steatite top is considerably less than 0·1 of an inch, and that required to pass five feet per hour through the complete burner is about 0·2 of an inch.

In the burner introduced by Mr. A. M. Silber the steatite top with wide holes (about one milli-

mètre, or ·04 inch) is also adopted; but the body of the burner is considerably elongated, and the so-called "cone" is long and cylindrical, with a curved top. A very essential feature in the Silber Argand is an air-tube introduced into the centre of the jet, which is said to carry a portion of the air to the upper part of the flame, and which certainly has a remarkable effect in steadying it. The chimney is 8 × $1\frac{3}{4}$ inches, and, in consequence of the form of the "cone," is kept so cool at the bottom that it may be handled without difficulty while the flame is burning. Chimneys of 10 inches high are also used, but, while the consumption of gas is thereby increased, the illuminating power per cubic foot of gas remains almost quite constant. Mr. Silber has discovered the remarkable fact that a globe or vase placed below his Argand increases the illuminating power considerably, and I have had an opportunity of verifying his statement, both as to common and cannel gas, the increase with the former being about a candle, and with the latter about $1\frac{1}{2}$ candles. The effect of placing a vase below an ordinary union jet was also tried, but no increase of light was obtained, while the flame showed a distinct tendency to "blow." That the flame of the Argand should have its illuminating power increased 6 per cent. by passing the gas through a glass vase (or cylindical metal box, which answers the purpose equally well) is a phenomenon which appears to be at present incapable of explanation.

The following Table gives the results of photometric tests of various Argand burners, with cannel gas of 26 candles illuminating power. From 3 to 4 cubic feet of gas per hour were burned in each case, and the result calculated to the usual standard of 5 feet per hour.

	Size of Chimney.	Illuminating Power.
German porcelain Argand with cone (40 small holes)	8 × $1\frac{3}{4}$	17·80
Leoni 40-hole burner, "adamas" top, with cone	7 × $1\frac{7}{8}$	18·18
Sugg-Letheby 15 holes in steatite ring, perforated gallery	7 × 2	18·86
American regulating Argand, brass, 40 very large holes	5 × 2	21·03
Sugg's "London" Argand, 24 holes, with cone and regulator	7 × $1\frac{3}{4}$	22·40
Silber 40-hole burner, steatite top, cone, and centre tube	8 × $1\frac{3}{4}$	22·54
Silber 32-hole burner, steatite top, cone, and centre tube	,,	23·08
Silber 24-hole burner, steatite top, cone, and centre tube	,,	25·04
Silber 24-hole burner, with glass vase below	,,	25·61

The following tests were made with various Argands in order to test the effect produced by the cone and centre tube of the Silber burner.

These tests show that the cone, by increasing the draught, enables a larger quantity of gas to be burned, an effect which could be obtained equally well by increasing the height of the chimney; and the air-tube of the Silber burner also produces a similar effect, increasing at the same time the heat and the illuminating power of the flame, and its stability. Indeed, the Silber burner without cone and centre tube, and especially when the latter is removed, gives so unsteady a flame that it is practically useless, while in its complete condition it gives the steadiest flame of any Argand yet constructed.

	Pressure at Inlet of Burner Inch.	Gas per Hour Cubic Feet.	Illuminating Power.	Illuminating Power for Five Cubic Ft.
Sugg's "London" Argand, 24 holes	0·19	3·30	15·00	22·73
Sugg's do., without cone..	—	2·60	11·80	22·70
Sugg's do., older pattern, 36 holes	0·17	4·00	16·75	20·94
Sugg's do., without cone..	—	4·00	17·00	21·25
Silber's 24-hole burner, complete	0·05	4·00	19·20	24·00
Silber's do., without cone, but with air-tube	—	4·15	19·00	22·89
Silber's do., without air-tube, but with cone ..	—	3·80	17·20	22·63
Silber's do., without cone or air-tube	—	3·40	13·10	19·26

A series of experiments were made in order to ascertain the relative dimensions of the inlet and the outlet of various burners. The upper steatite portion of each burner was removed and fitted up in a little bit of apparatus extemporised for the purpose, so that gas could be passed through the holes, while the bottom portions were simply screwed on in the usual manner, and the gas allowed to escape without lighting it. In all the trials the pressure of the gas was maintained steadily at 0·2 of an inch of water. The numbers represent cubic feet of gas per hour:—

	Bottom.	Top.	Complete Burner.
Sugg-Letheby 15-hole burner ..	16·7	28·7	14·6
Sugg 24-hole standard "London" Argand	4·9	28·8	4·5
Sugg 36-hole (older pattern) ..	6·1	29·1	6·0
Silber 24-hole..	17·7	29·5	17·0
Silber 40-hole..	19·1	28·8	18·7

These results show that the pressure of the gas is checked much more efficiently at the bottom of the burner by Sugg's arrangement than by that of Silber, and, in fact, the latter has usually attached to it a small regulator, adjustable by a screw, without which, and when regulated only by a stopcock, a disagreeable hissing noise is produced by the paasage of the gas through the almost-closed stopcock, unless the latter is far removed from the burner.

The "Bec à Bengel," or Bengel Argand burner, used for gas-testing in Paris, has a porcelain top

with 30 rather small holes, a brass cone, and at the bottom what is called a "panier," constructed of porcelain, and pierced with numerous small holes for the admission of air. The chimney is 8 × $1\frac{3}{4}$ inches. With 26-candle gas it burned 2·5 cubic feet, and gave a light of 10·8 candles, or, for 5 feet per hour, 21·6 candles.

Sugg has constructed a series of "London" Argands, burning from 3 to 12 cubic feet per hour of common gas, and from $1\frac{1}{2}$ to $7\frac{1}{2}$ cubic feet of cannel gas per hour. These from A to I resemble in every respect the standard "London" burner already described; K has, in addition, a single or rat-tail jet in the centre, and that marked double is formed of two concentric Argands. They gave the following results:—

Burner.	Number of Holes.	Chimney.	Height of Flame.	Gas per Hour.	Illuminating Power.	Illuminating Power for Five Cubic Feet.
A	15	6×$1\frac{5}{8}$	$2\frac{1}{4}$	1·85	7·67	20·73
B	18	,,	$2\frac{3}{4}$	2·65	11·90	22·45
C	21	6×$1\frac{3}{4}$	3	2·85	12·63	22·16
D	24	7×$1\frac{3}{4}$	3	3·25	13·74	21·14
E	27	,,	3	3·40	14·67	21·57
F	30	,,	$3\frac{1}{4}$	3·72	15·97	21·48
G	33	8×$1\frac{3}{4}$	$2\frac{3}{4}$	4·50	19·13	21·25
H	36	9×2	4	5·05	21·17	20·96
I	40	,,	4	5·30	22·30	21·04
K	42	,,	$4\frac{1}{2}$	6·50	28·40	21·84
Double.	54—21	10×$2\frac{1}{2}$	6	7·80	36·40	23·33

It is right to state that all these burners are constructed to burn common rather than cannel gas. A Silber Argand of 24 holes, with chimney 8 by $1\frac{3}{4}$, was tested at the same time for comparison, and gave, for a consumption of 3·75 cubic feet per hour calculated to 5 feet, an illuminating power of 24·02 candles, a some what higher result than was obtained with any of Sugg's series, and proving that Silber's Argand is well adapted for burning cannel gas.

Experiments were made in order to ascertain the loss of light resulting from the use of globes of different kinds, and of various shapes. The loss is always considerable, and in many cases excessive, and it results partly from the absorption of light from the material of the globe, and partly from the draught caused by the ascension of the heated air in the confined space. As regards material, a piece of clear window-glass, held in front of a gas-flame, diminishes the light to the extent of about 10 per cent.; but in the case of a clear globe it is, in some cases, less, owing to the reflection from the surface furthest from the photometer. Globes frosted or ground all over, technically known as "moons," absorb about 25 per cent. of the light when well shaped, and opal or "cornelian" globes 40 to 50 per cent., according to the thickness and quality of the glass. The following results were obtained with globes of different sizes ground all over, and show the effect of increased draught in diminishing the light:—

	Per Cent.
6-inch globe caused a loss of	25
$7\frac{1}{2}$,, ,, ,, ...	$27\frac{1}{2}$
10 ,, ,, ,, ...	38

All these globes had the usual-sized openings below—about $1\frac{3}{4}$ inches in diameter. Experiments were made with clear $7\frac{1}{2}$-inch globes, having openings below, varying from $2\frac{3}{8}$ inches to 1 inch in diameter. The source of light was a Brönner bat's-wing, No. 5 top, No. 4 bottom, burning, under a pressure of 1 inch, 3·35 cubic feet of gas.

		Candles.	Per Cent.
The naked flame gave a light of		16·8	
With clear globe, opening below	$2\frac{3}{8}$ in.,	15·4;	loss 8·3
,, ,,	$2\frac{1}{4}$,,	15·2;	9·5
,, ,,	2 ,,	13·6;	19·0
,, ,,	$1\frac{1}{2}$,,	13·0;	22·6
,, ,,	1 ,,	12·0;	28·6

With the two larger-sized openings, the flame was perfectly steady, with that of two inches there was a slight flickering caused by the draught; this was more marked with the $1\frac{1}{2}$-inch opening, and was excessive with that of one inch, making the flame practically useless as a source of light. It is evident, therefore, that the openings of the globes should be as wide as possible, and not less than $2\frac{1}{2}$ inches. The cornelian globes used in Brönner's system of gas lighting have an aperture of $2\frac{3}{8}$ inches diameter, and Sugg has introduced globes of similar material which he calls "Albatrine," but with openings of about 4 inches diameter. These globes are constructed of various sizes, to suit certain burners, both bat's-wing and Argand, and the combinations are known by certain names, such as the Westminster, Viennese, Frankfort, Italienne, Parisienne, &c. Some of these arrangements are fitted with regulators, with the intention of maintaining a constant pressure.

One of the difficulties connected with gas illumination is that the pressure in the mains varies considerably in different parts of a town, and at different hours of the day and night. One result is that a system of lighting, adapted for a part of a town situated in a low level, will show inferior results in a more elevated situation. A rise of 10 feet gives, roughly, a tenth of an inch of increase of pressure, so that it may easily happen that in the same town or city the pressure in one place may be one inch, while in another it may be $2\frac{1}{2}$ inches. Again, the pressure of the gas, as sent out from the gas-works, is altered from time to time, in accordance with the consumption, and as public works, shops, &c., are suddenly lit up or extinguished at certain hours, private consumers are annoyed, in the one case by the falling off in the amount of light, and in the other by a flaring flame and hissing sound, both of which are very irritating. The cure for these evils is to be found in the use of governors or regulators. Every district of a town, the elevation of which is such as to affect appreciably the pressure of the gas, should have a governor, which may either be self-acting, to maintain a constant pressure throughout the day, or to vary sympathetically with the governor at the gas-works. Many of these have been invented, among which may be mentioned those of Cathels, Peebles, and Foulis. The pressure in the mains should not be reduced below 12 or 14-tenths of an inch, but as even that is too high a pressure for the economical burning of gas, each house should have a regulator in order to reduce the pressure constantly to about 7 or 8-tenths. Some of these regulators are dependent on the action of the gas upon a broad leather disc, attached

to which is a ball and socket valve, while others have metal or glass bells floating in mercury, and acting upon a valve of the same kind. Both of these work satisfactorily when properly constructed. Among the best dry regulators are those of Sugg of London, and Peebles of Edinburgh, while the best mercurial governor that I have seen is that of Busch of Oldham. In the case of public works and other buildings consisting of several floors, a regulator should be placed on each floor. Street lamp regulators are of great importance, and great attention has been given to the perfecting of them by various ingenious mechanicians. The kind the largest number of which are in use at the present time resembles the dry house regulator already mentioned, the construction being quite similar. These little instruments are made by a great many gas engineers, among whom Sugg and Peebles may be named. The principle involved in the action of the apparatus will be at once understood by a glance of the sectional drawing I have placed upon the wall. It is a regulator, not of volume, but of pressure, and hence the quantity of gas consumed in any street lamp provided with it depends upon the burner. There is an objection to this regulator, and it is a serious one—the leather diaphragm becomes in time hard and stiff, and ceases to act freely, and, unless it be renewed at intervals, say of 12 or 18 months, the instrument is by no means satisfactory. The next street lamp regulator in point of period of introduction is Giroud's rheometer. This beautiful little instrument, which delivers a constant volume of gas, consists of a short cylinder containing glycerine, in which floats a bell of very thin metal, and formed at the top into a cone, the apex of which passes through an orifice in the cover of the cylinder. In the bell itself there is a small hole, through which the supply of gas to the burner must pass. An increase of pressure causes the bell to rise, and the cone to enter the orifice above, thus reducing the area of the aperture through which the gas has to make its way to the burner. The regulation of the rheometer is very perfect, but it ceases to be effective in some eventualities which ocasionally occur.

The most recent street-lamp regulator may be called a dry rheometer. It delivers, like the instrument just noticed, a constant volume of gas, but the bell, or substitute for it, instead of floating in a liquid, is simply supported while in action by the pressure of the gas. A regulator of this kind is first indicated in the book published by Giroud, but I am not aware that he ever actually reduced his idea to practice. Victor Bablon, of Paris, patented in 1875, "an apparatus for regulating the flow of lighting gas," in which the float, if it may be so called, is a disc of thin metal connected to a small hollow spindle. It has been introduced somewhat extensively in France, but is almost unknown here. It works with somwhat greater friction than the "needle governor" of Peebles, which is, to my mind, the perfection of gas regulators. In a little cylinder stands a so-called needle, on th point of which rests a flanged cone of exceedingly thin metal. At one side of the cylinder there is a small tube leading away the gas, and by means of a screw working into the side tube, the instrument can be made to deliver any desired number of cubic feet, which it does with surprising accuracy, provided that the pressure of the gas is not less than eight-tenths of an inch. In trials I have made I have not found the variations of volume at different pressures to exceed 1 per cent. With such a regulator as this, it would be possible to employ Argand burners for street lamps. These burners, when of the best kind, are exceedingly sensitive to quantity of gas. If you have a Sugg or Silber Argand regulated so as to be near the smoking point, and so giving the highest illuminating value that the gas is capable of yielding, the smallest additional supply of gas will cause the flame to smoke. I have here one of Silber's Argands fitted to a needle governor, and you will have an opportunity of seeing the regularity of the flame under different conditions of pressure. I should have mentioned, before the needle governor, the invention of Flürscheim, patented in this country by Borradaile in 1877, but it resembles Bablon's instrument closely, and differs from it chiefly in details.

One other description of regulator remains to be described—that which may be used in connection with the ordinary burners in our apartments. It must necessarily be small, in fact, it should not be much larger than the burner itself. Sugg has, for a number of years, supplied a regulator of this kind, consisting of a leather diaphragm with ball and socket arrangement, but it is a little uncertain in its action, and, so far as my experience goes, not altogether satisfactory; and, besides, it is too large to be useful except as part of a special system of lighting. Peebles has been endeavouring to reduce his needle governor to similar dimensions, and although he does not claim to have yet produced an altogether perfect instrument, in so far as it requires about ·8 of an inch of pressure to put it in action, he has great hopes that he will yet be successful.

In this paper I have attempted to indicate the process recently made in the way of developing the photogenic power of coal gas, and the direction in which further improvements may be looked for. I shall be glad if my remarks have the effect of attracting attention to a subject of such interest and importance.

Before concluding, I wish to make one other remark. Last night, on arriving in London, I saw the Thames Embankment illuminated by electricity, and was very much satisfied with the appearance. Then I went across Waterloo-bridge, and saw those lamps in the Waterloo-road; and I must say I was very much struck with the magnificent light afforded. That certainly was a step in the right direction, although I am of opinion that we are striving too hard to light up our streets. I do not see any necessity for lighting up the streets to make them equal to daylight. What we want is to see where we are going, to avoid being robbed at night, and so on, but I think it is a great mistake that we should strive to make our streets as light as they are during the day. However, there may be economy in these very large burners, and I think there is, though I have not tested them, and I am not able to speak positively. We are very much obliged to Mr. Sugg for lending us these two lamps to-night.

DISCUSSION.

Mr. Sugg said he believed the Sugg-Letheby burner was the first step in the direction of consuming gas at

a low pressure, after which came Brönner's and Williamson's, as described by the lecturer. Those two burners included nearly every kind of flat-flame burners which had an obstruction to prevent gas issuing too rapidly, with the exception of the hollow-top burners which he had invented, but which were not mentioned in the paper; these burners made the flame taller, and consequently gave higher illuminating power. In Leoni's burner the top was not made of steatite but of adamas, a composition of magnesia and silicate of potash, totally distinct from steatite, which was a kind of French chalk. In the soft state this could be turned in the lathe like ivory, but when heated up to 2,000° it became harder than the hardest steel, retaining its colour and form. The Silber burner, he thought it only right to say, was really a Sugg burner. The lower you could get the pressure in flat-flame burners, the greater would be the illuminating power, and that applied both to cannel and common gas. Cannel gas, he believed, was now being burnt in the large burners before them, and was giving the highest result which he thought had been achieved by any burner, nearly $4\frac{1}{2}$ candles per cubic feet of gas consumed. The gas was only equal to about 22 candles, therefore there was a difference between what would be the result of 22-candle gas and 30-candle gas, but he had found that, with even the highest illuminating power, you must have a low pressure to burn it, and you could only get that with an Argand burner. With regard to the large burners exhibited, one was a double London Argand burner and the other a quadruple, each being provided with a regulator having a metallic disc, the disc fitting inside a kind of cylinder which had a play of nearly one millimètre round the disc, and, under ordinary circumstances, enough gas would pass round to supply the burner. It was made tight in the following way. In the edge of the piston there was a little groove turned which was filled with oil, and the capillary attraction of the oil to the side made a perfectly tight joint under the pressure of gas, which would not be more than ·7 to ·8 of an inch. That kept the joint perfectly sound, and the disc rose and fell according to the pressure. The tops of all those burners were made of steatite. They were the same as the London burners, only the number of rings was increased to four, and very shortly there would be one produced with five. There had been one made with eight rings, but at present it was imperfect; when perfected it would give a light from 1,000 to 1,200 candles.

Mr. Ford, referring to the closing remarks of the lecturer, said he thought they ought all to feel pleased that the question of street lighting had come forward so prominently. The spirit in which it had been taken up by practical and scientific gentlemen, notably by the Chairman, had brought a good attendance that evening, and would cause the public to inquire and support gas engineers in developing and bringing gas to a state of perfection. Had it not been for the street lighting in Paris and other towns by electricity, they would not have gone to such an expense in the Waterloo-road and in many public buildings. He hoped gas engineers would be supported by corporate bodies in dealing with the question of street lighting, and then private customers would understand the value of gas, and give their support to the experiments.

Mr. Lawrence Hamilton, dealing with the question of lighting libraries and studios, said the inverted saucer was an admirable contrivance for saving the eyes of those who worked long and late. He believed Mr. Brudenell-Carter, the eminent surgeon, had said that if a solution of alum were placed by the side of any common gas burner, in a flat glass vessel, 20 to 30 degrees of heat might be saved without losing any light.

Mr. Silber complimented those who had been engaged in improving the light by gas on the progress which had been made and exhibited that evening. He did not believe they had ever seen a light produced from gas equal to that from the two pedestals exhibited that evening. His knowledge of gas did not begin before 1869, but having since paid considerable attention to it, he had come to the conclusion that amazing progress had been made. Burners up to eight rings were not new, though the results shown were, because in burners formerly used it was considered they should be of certan lengths, which rendered them totally unavailable for ordinary purposes; in fact, they were only suited for lighthouse illumination. They had not come to discuss simply the question of one burner maker *versus* another, for the Society of Arts' rooms were not the place for that purpose, but to discuss what was for the public use and benefit. They must all be struck with the beautiful burners before them; but still they must put the practical question, Were large lights desirable, and what was wanted for the illumination of the streets? The public would have to inquire what they obtained for their money. By having a large light, giving from 200 to 1,000 candles, placed in one lantern, did they obtain a better result than with the lights now used, giving 12 to 16 candles, and consuming 5 ft. of gas per hour. They must also make a comparison with the electric light; but, as they had the question of gas before them that night, he would deal with that only. He was under the impression that too large a light, concentrated in one spot, was a disadvantage, because they lost so much in the space the light had to travel. He would not stay to give the well-established figures as to the enormous quantity of light lost in the distance it had to travel, but he believed when the present agitation had gone by—for although he hoped the electric light would be improved for the benefit of society at large, it was not shown that it could be used for practical purposes—they would not find local boards in favour of large lights, whether electric or gas. The lamps exhibited by Mr. Sugg, giving a light equal to 16 candles in the Argand burner, he thought would be ample for street purposes. He did not know whether the specimens of street lamps, such as those in Piccadilly, which Mr. Sugg had brought forward, would answer all the required purposes, but the light was certainly ample. With regard to burners, it was known to everybody who had studied the matter that the greatest advantage was obtained from gas burnt with the lowest possible pressure. He did not dispute that Mr. Sugg might have been the first or one of the first to introduce that system, but it had been stated in open court that to be consumed advantageously the gas must pass through a narrow channel. But that position was now entirely reversed, because in the burner exhibited with the glass vase the opening might be as large as you liked, the larger the opening the better the result. A mistaken theory had gone forth, and become almost universal in England, and had not been questioned until Professor Wallace came forward and said—why not construct a glass vessel which anybody can see? He did not blame anyone for adopting a theory which had been supported by scientific men, but this burner showed the mistake of that theory.

The Chairman, in moving a vote of thanks to Dr. Wallace, said he quite agreed that none of them could say that they had decided exactly the amount that was desirable either in the public streets or houses. It was for those who had the lighting of the public streets to say how much they required, and for private individuals after the experience of the electric light to say how much they wished in their own houses. Those of the audience who were gas consumers would have found that night some explanation of the very great difference which occasionally occurred in their gas bills. Dr. Wallace had shown that it was possible for one man to have his house brilliantly and satisfactorily lighted, for the same amount of money as that spent by another man in a house of equal size, and with an equal number of burners, but who was constantly grumbling at the unsatisfactory light. He trusted that gas com-

panies would assist in the education of consumers as to the best methods of using gas, and concluded by moving a vote of thanks to Dr. Wallace.

The resolution having been unanimously passed,

Dr. Wallace replied, thanking Mr. Sugg for his remarks. As to the hollow-top burner, he knew it, but had omitted to describe it, though he had one on the table. He was not aware Mr. Sugg was the inventor, and was glad to receive the information. He had always stated that the Leoni burner was made of adamas, and he concurred in Mr. Silber's remarks with regard to pressure. The gist of his paper had been to impress upon them the desirability of lowness of pressure in order to get a good burner, and this Mr. Sugg had been very successful in producing. He thanked them cordially for the attention they had paid to him.

Mr. John Hayes writes to call attention to Webster's gas burner and system of lighting, as he had no opportunity of bringing it forward at the meeting.

INDIAN SECTION.

Friday, January 31; Andrew Cassels, Member of the Indian Council, in the chair.

The paper read was—

THE QUEST AND EARLY EUROPEAN SETTLEMENT OF INDIA.

By **Dr. George Birdwood, C.S.I.**

Preface.

I have for some time been officially engaged in the preparation of a report on the supplementary miscellaneous records of the India-office, relating to the East India Company from the date of the incorporation of the "Old" or "London Company" in 1600, to 1708-9, when it was amalgamated with the then recently chartered "English" or "New Company."

These old records consist of the charters and firmans of the company, the minutes of their meetings, copies of the commissions to their servants, the diaries and consultations of their supercargoes and factors, their account-books of purchases, and sales, and deliveries, and imports and exports, and salaries, the lists of their shareholders, and their general correspondence. The better to understand the value and interest of these documents, I found it desirable to examine all the works of travel and history, and afterwards of poetry and general literature, of the hundred years—which may be designated the factory period—covered by them. The present paper is the result of this examination. It is not the official report on the "old records," but a note written in elucidation of the report.

The title given to it bespeaks the conclusion to which my reading has led me, that the history of modern Europe, and emphatically of England, has been the quest of the aromatic gum resins, and balsams, and condiments, and spices of India and the Indian Archipelago.

First, I treat of the old travellers from after Cosmas Indicopleustes to the discovery of Da Gama; then of the Portuguese Asiatic Empire; next of the Dutch in the East; and, finally, of the English in India, under the two heads of their Factories, and the Conquest of India.

I give all the old travellers' routes, and the identification of the places and Eastern products they name (nearly always taken from Colonel Yule's "Cathay, and the Way Thither," and his "Book of Ser Marco Polo"); and their remarks on the routes of mediæval commerce, and its emporia in the Eastern seas and Western Asia. I shall skip a good deal of this to-night, as my paper is more for private reference than public reading, and I only hope that there will be enough of general interest in what of it I read to make the hour within which I shall be careful to confine myself pass agreeably to my hearers.

The Old Travellers.

The earliest trade between Europe and Asia was the overland trade carried on by the Phœnicians along the caravan-road, by which they are supposed to have originally emigrated, between B.C. 2500 and 3000, from the Persian Gulf to the narrow Mediterranean shore of Syria. The adoption, by nearly every civilised nation of the ancient world, of the alphabet invented by the Phœnicians is the simplest, most striking, and surest proof of the wide extent and deep abiding influence of their vast and marvellous commerce. By it also the Eastern arts of pottery, ivory turning, glass making, enamelling, and wood carving, were, at last, carried into the remotest recesses of Germany and Scandinavia, and profoundly influenced the primitive civilisations of those countries. The appearance of bronze arms and implements, after stone ones, among the prehistoric remains of Switzerland and Denmark, which is generally said to be due to the displacement of the primæval savage tribes of the West by the immigration of new races of a higher civilisation from the East, probably, rather marks the age of the earliest Phœnician intercourse with Europe. When gradually the commerce between the East and West took to the routes by the Persian Gulf and the Red Sea, it still remained in the hands of the Phœnicians; and it continued in their hands,* and in these of their natural successors, the Arabs, who had shared it with them in the Eastern seas from the first dawn of history, to the discovery, by the Portuguese, of the sea passage to India round the Cape of Good Hope, A.D. 1487-98.

It was not, however, until the date of Alexander's invasion, B.C. 327, that the people of the West acquired any real knowledge of India. Alexander's expedition and the embassies of Seleucus and the Ptolemies carried our knowledge of India from Afghanistan and Beluchistan to the delta of the Indus, and the lower plains of the Ganges. Arrian's "Periplus of the Erythrean Sea" (*circa* A.D. 200) extended it to all the ports of Guzerat and Malabar, and to Masulipatam on the Coromandel coast, and "the Gangetic Mart" of Chittagong at the head of "the great bay" of Bengal. Cosmas Indicopleustes, who traded in the Red Sea about A.D. 535-50, gives a very clear account of the commerce between India and Egypt in his day. He says that the produce of Kalliana (Callian, represented in mediæval times by Tannah,

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* The sea-fight of Actium, B.C. 31, may be arbitrarily fixed as the term of Phœnician commerce in the Mediterranean; but it really went on, in other hands, until it was again taken up by Saracens, even as it had survived in full vigour the destruction of Tyre, B.C. 586 and 332, and of Carthage (and the pillage of Corinth by Mummius the same year) B.C. 146.

and in modern by Bombay) is brass (vessels), Sisamum (*sissoo*) wood, and cotton stuffs; of Sindus, castorin or musk, and spikenard; of Male (Malabar) pepper; and that from Tzinitza (China) and the other countries beyond Sielediba or Taprobane (Ceylon) came silk, lign-aloes, cloves, nutmegs and sandal wood.

Our next notices of India are by the Arabs. The voyages of "Sinbad the Sailor" in the "Thousand and One Nights" belong to the ninth century, when the commerce of the Arabs, under the Caliphs of Baghdad, in the Eastern Seas, was at its highest activity. In his first voyage, Sinbad reaches the country of the Maharajah, a title given so far back as the second century to a Hindu king, whose vast monarchy comprised the greater part of India, and the Malay peninsula, and Sumatra and Java in the Indian Archipelago, and whose title continued to be borne afterwards by one of the sovereigns of the disintegrated empire, who reigned over the kingdom of Bijanagar or Vijanagar, known later as the kingdom of Narsinga. In Sinbad's second voyage, mention is made of the kingdom of Riha (considered by some to be the Malay peninsula) and the manner of the preparation of camphor is accurately described. In the third voyage the island of "Silaheth" (Malacca) is mentioned. In the fourth he was carried to a country (Malabar) where he found men gathering pepper, and from it he went to the island of "Nacous" (the Nicobars) and on to "Kela" (Quedah). In the fifth voyage he is shipwrecked on the "island" (country) of "the Old Man of the Sea," probably somewhere on the Concan coast. Thence he crossed the sea to the Maldives, and back again to the pepper country of Malabar, passing on to the peninsula of Comorin, where he found "the aloes wood" called *santy* (sandal wood) and afterwards to the pearl fisheries of the Gulf of Manaar, whence he travelled back to Baghdad. In the sixth voyage he visited an "island" (country) where were "superb aloes" trees of the kinds named "*santy*" and "*comary*," and the island of "Serendib" (Ceylon), which was also the bourne of his seventh and last voyage. The Abbé Renaudot in his "Anciennes Relations des Indes et do la Chine" (Paris, 1718) gives the notes of travel of two Arab merchants who apparently visited India and China in the ninth and tenth centuries, and are the first among Western writers to make mention of tea (*tcha*) and porcelain. They also mention arrack and rice. Slieman, the author of the first part of the "Relations," was a merchant of Bussorah (which had been founded by the Caliph Omar, A.D. 635, to encourage the Persian Gulf trade) about A.D. 851. Colonel Yule, in the preliminary essay to his "Cathay, and the Way Thither," published by the Hakluyt Society in 1866, says that he gives a tolerably coherent account of the seas and places between Oman and China; "the Sea of Persia," "the Sea of Lar" (which washes Guzerat and Malabar), "the Sea of Harkand" (from the "Dibajat" or Maldives and "Serendib," or Ceylon, to "àl Ramni" or Sumatra); the "Lanjabalus" or Nicobar Islands, and the "two (Andaman) islands in the Sea of Andaman" and of "Kalahbar" a dependence of "Zabaj" (Qedah); "Batumah" (Natumah Islands), "Kadrang" (Siam) Sanf (Chiampa and Cambojia) and "Sandar Fulat" or Pulo Condore. The mart in China frequented at this time by the Arabs was Khanfu, the seaport of Hangchau. Abu Said, of Siraf, in Faristan, the author of the second part of the "Relations," wrote in 916, and he begins by remarking the great change in the commerce of the East that had taken place in the interval since Sulieman wrote. A rebellion had broken out in Kanfu which had entirely stopped the Arab trade with China, and carried ruin to many families in Siraf and Oman. He gives also an account of a visit which an acquaintance of his own had made to Khumdan (Changgan or Singaufu) the capital of China. Ibn Khurdadbah, who flourished about A.D. 869-885, is the first who makes mention of galangal and kamala, and he also mentions porcelain and sugar-cane, pepper, aloes wood, cassia, silk, and musk. Masudi, of Baghdad (A.D. 890-956), who visited India and China about A.D. 916, mentions nutmegs, cloves, cubebs, camphor, areca nuts, sandal wood, and aloes wood, as productions of the Indian Archipelago. Edrisi, of Spain (A.D. 1099-1186), also mentions tea, porcelain, and the fine cotton fabrics of Mobbar (Coromandel), the pepper of Malabar, the cardamoms of Ceylon, the camphor of Sumatra, nutmegs, the lemons of Mansouria on the Mehran (Indus), the assafœtida of Afghanistan, and cubebs as an import of Aden. He names the Concans the country of Sadg, *i.e.*, sag or teak, and is the first to mention China by that name. The Jewish traveller, the Rabbi Benjamin of Tudela, who travelled in the East between the years 1159 and 1173, when already the empire of Abasside Caliphs was rapidly declining, and the Turks were gaining the ascendancy at Baghdad, would appear not to have proceeded beyond the island of Kish (not to be confounded with Kishm), which for ages was the real terminus of Indian trade through the Persian Gulf. All he relates of India and China is, according to Colonel Yule, mere hearsay. Kish he describes as the great emporium "to which Indian merchants bring their commodities, and the traders of Mesopotamia, Yemen, and Persia all sorts of silk and purple cloths, flax, cotton, hemp, *mash* (*phascolus radiatus*), wheat, barley, millet, rye, and all sorts of comestibles and pulse, which articles form objects of exchange. Those from India export great quantities of spices." He refers to the pearls of the Bahrein Islands, and to the pepper, cinnamon, ginger, "and many other kinds of spices" produced in southern India. The islands of "Khandy," by which he is supposed to mean Ceylon, he places at 22 days' distance from Kish, and China 40 days beyond "Khandy."

Ibn Batuta, of Tangiers (b. 1304, d. 1377-78), was the greatest traveller of all the Arab nation. He spent 24 years (from 1325 to 1349) in travelling throughout the East, from Tangiers across Africa to Alexandria, and in Palestine, Syria, and Arabia; and down the east coast of Africa to Quiloa; and across the Indian Ocean to Muscat, Orman, Kish, Bahrein, and El Katif; and through central Arabia to Mecca and Jeddah; and again in Egypt and Asia Minor; and across the Black Sea to Caffa, or Theodosia, Azov, or Tanna, and on past "the hills of the Russians" to Bolgar on the Volga, but did not dare to penetrate further northwards into "the Land of Darkness." Returning south to "Haj Tarkhan" (Astrakhan), he proceeded westward to

Soldaia and "Istambul" (Constantinople), whence, returning to Bolgar, he travelled eastward on to Bokhara and through Khorassan, to Cabul, Multan, and Delhi, where he remained eight years (1334-42). Being sent by the Sultan Mahommed Tughlak on an embassy to China, he embarked from "Kinbait" (Cambay), and after many adventures at Calicut (where he was honourably received by the *Samari*, or Zamorin) and "Hunawar" (Onore), and in the Maldive Islands, and Ceylon, and Bengal, he at last took his passage for China in a junk bound for "Java" as he calls it, but in fact Sumatra. Returning from China, he sailed direct from the coast of Malabar to Muscat and Ormuz, and travelling by Shiraz, Ispahan, Bussorah, Bagdad, Tadmor, Damascus, Aleppo, Jerusalem, and Mecca (for the fourth time), Egypt, and Tunis, at last reached Fez again, after an absence from Marocco of half his lifetime. Subsequently he spent six years in visiting Spain and Central Africa, where he was a guest of the brother of a countryman of his own from Ceuta, whose guest he had been in China. "What an enormous distance lay between these two!" he exclaims. Such a fact well illustrates the extended ramifications of the Arabian commerce between the East and the West, before it was subverted by the rise of the dominion of the Ottoman Turks and the maritime discoveries of the Portuguese. Notwithstanding the great interest and importance of the travels of Ibn Batuta, they altogether failed in attracting attention and influencing the desire, which soon afterwards began to agitate the Genoese, to trade direct with India. The first detailed account of them was only published in Europe in 1808. He says that in his time Cairo was the greatest city in the world "out of China," and that the finest trading ports he had seen were Alexandria in Egypt, Soldaia, or Sudak, in the Crimea, "Koulam" (Quilon) and Calicut in India, and Zayton (Chinchau) in China. He describes Aden as a place of great trade, to which merchant ships of large burden resorted from Cambay, Tannah, and all the ports of Guzerat and Malabar. Among the productions of the Indian Archipelago, he describes gum benjamin, aloes wood, cloves, camphor, and sandal wood, and enumerates also cocoa-nut palms, areca-nut palms, jack trees, orange trees, mangoes, and jamums (*Eugenia Jambolana*). Porecelain, he says, is made in China nowhere except in the cities of Zeyton and Sinkalan (Canton). It is exported to India and elsewhere, passing from country to country until it reaches Marocco. Abulfeda, of Damascus (1273-1331), the celebrated Arabian geographer, also makes mention of the abundance of pepper grown in Malabar, and the fine cotton manufactures of Coromandel. He divides Hindustan into Al Send, the country of the Indus, and Al Hend, the country of the Ganges. North of India, beyond the Himalaya, the Arab geographers knew, under the name of Marwaralnahar (*i.e.*, *Marwar-al-nahar*, "beyond-the-river"), the vast plains extended westward from the Pamere Steppe Attai mountains, watered by the Oxus and Janartes, shown on maps of ancient classical geography as *Scythia intra Imaum*, and named by modern geographers, Transoxiana. Abulfeda describes the plain of Samarcand "as the most delightful of all places which God has made." Beyond this region, Asia (*Scythia extra Imaum*) was occupied by the Turks, a name used by Arab geographers in as diffuse a sense as that of Scythians by the ancients, and Tartars by ourselves, and which is applied by them to the same Turanian hordes, included in the Hebrew Scriptures under the names of Gog and Magog, whose secular irruptions into the south lands of Asia, and sometimes into Egypt, constantly, from the earliest ages, interrupted the westward extension of Aryan civilisation. In the national legends of Persia, the Oxus is fixed as the everlasting boundary between the Aryan and Turanian races; but, in fact, the result of their immemorial struggle for the possession of the maritime table land of Iran, has been to leave the Turanian race supreme over all the wide regions between the Indus and Oxus, and from the steppes of the Caspian Sea to the shores of the Mediterranean, Red Sea, and Persian Gulf; while under the Mogol Emperors of Delhi their political supremacy in the East was extended beyond the Nerbudda and Kistna. The fancy of the Arabian writers transformed the Gog and Magog of Ezekiel into two enormous giants, *Yajuj* and *Majuj*, who had fortified themselves within a stupendous castle at the extremity of Asia. Its walls, which, formed of iron and brass, seemed to touch the sky, are evidently the Altai mountains, out of which the hordes of barbarians had so often issued to devastate the world. Other traditions of these destructive irruptions were probably the origin also of the mediæval legends of the unclean "Shut-up Nations."

After the overthrow of the Western Empire by Odoacer, A.D. 476, and during the struggles between the Eastern Empire and the Persians and Saracens, the overland trade with the East languished until the consolidation of the Saracenic power at Cairo, Damascus, and Baghdad; after which the trade by the Persian Gulf was again thrown into disorder, from the time of the ascendancy of the Turkish Guard at Baghdad, A.D. 866. The Seljukian Turks, under Togrel Beg, conquered Persia, A.D. 1042. The Tartars under Hulaku Khan, a grandson of the famous Chingiz Khan (b. A.D. 1163, d. A.D. 1227), took Baghdad, and overthrew the Eastern Caliphate A.D. 1258. Palestine was conquered by the Fatimite Caliphs of Egypt, A.D. 969; and in consequence of the persecution of the Christians by Hakem, between A.D. 996 and A.D. 1021, Peter the Hermit began preaching the first Crusade against the Saracens in 1094. The eighth and last Crusade of St. Louis was concluded in 1274. It was during these times that Venice, which was founded about A.D. 452, by the last fugitives from the vengeance of Attila the Hun, established their commercial relations with Alexandria and Constantinople. So early as A.D. 555, Venice had imported silks from the East, and from A.D. 802 dates her great trade in Eastern spices, drugs, and silks. Genoa had entered into the trade of the Levant even before Venice; and in the contests between the Greeks and Latins at Constantinople, having, contrary to Venice, sided with the Greek Emperors, obtained from them Pera and Smyrna, and Theodosia, or Kaffa, in the Crimea, and Tana, or Azoff (the ancient Tanais), at the mouth of the Dar, as the emporia of its trade with India and the East, by Persia and the ports of the Black Sea. About A.D. 1306-15 it began a regular trade with Trebizonde, and in its zenith possessed also Mar-

seilles, Corsica, and Elba. It was always successfully kept by Venice from establishing commercial relations with Alexandria for the Indian trade by Aden. It was during the suicidal rivalries between Venice and Genoa that Florence, under the wise administration of Cosmo de Medicis, obtained its splendid participation in the Mediterranean traffic with the East. The list of goods sold at Pera, given in the seventh chapter of the "Pratica della Mercatura," published in 1340, by Francesco B. Pagolotti, a factor in the service of the Bardi of Florence, is the most detailed account we possess of the Oriental trade of Constantinople in the fourteenth century. Both Genoa and Venice derived great wealth and power from their co-operation in the Crusades, and both suffered immensely from the capture of Constantinople by the Ottoman Turks, A.D. 1453, and Venice yet further, in consequence of the annexation of Syria and Egypt to the Ottoman Empire by Selim, A.D. 1516-17. It was in the interval between the fall of Constantinople and the Turkish conquest of Egypt that, in consequence of the ports of the Black Sea being closed to the Genoese, and all other nations, the Indian trade by the Red Sea, which had been encouraged by every means under the strong government of Saladin (1173-93) and his successors, reached its greatest development in mediæval times. When Venice, A.D. 1475-87, acquired possession of Cyprus, Famagusta became the emporium of its overland trade with the East, both through Egypt and Syria, and continued to be the first commercial city of the Levant, until taken by the Turks A.D. 1570-71.

The Hanseatic League is generally dated from A.D. 1240-41, when Hamburg joined it; but an earlier confederacy existed among the once pagan cities of East Germany—Bardewic, Julin, Staden, Winet, and others—whose very names have now almost disappeared from history, and which continued down to Christian times the yet more ancient Phœnician trade, by which the yellow amber of the Baltic shores was carried by caravans across Europe to the mouths of the Po, and articles of Asiatic, and later of Etruscan and Greek art, were distributed throughout Germany and Scandinavia to "utmost Thule." In the time of the Goths and Vandals, Winet became the universal mart of Eastern Europe, and the Asiatic trade through Russia; and when it was finally destroyed, together with Julin, by the Danes, about A.D. 1169, its pagan merchants withdrew to the new Christian cities which were founded on or near the shores of the Baltic during the twelfth century; and thus began that commercial association of these cities, under the headship of Lubeck, which afterwards developed into the Hanseatic League, the first object of which was to protect the confederated cities from the pirates of the Baltic Sea. The word "Hansa" simply means a "society," "company," "association," or "corporation." Copenhagen (*i.e.*, chipping, chaffering, or chapman's haven) was founded about the same time, and always proved a powerful competitor with the Hanse towns for the commerce of the Baltic. When Winet was destroyed, the Swedes of the Island of Gothland are said to have carried away whatever of its ruins that was curiously carved and wrought in iron, brass, and marble, and its great bronze gates, and to have used them in the architectural decoration of the town of Wisby, which also, in the twelfth and thirteenth centuries, became a great entrepôt of the commerce, between the East and West, through Russia. Consul Perry, in his highly interesting "Report on the Trade and Commerce of the Island of Gothland," dated December 10, 1873, writes:—"As far back as the eleventh century, Gothland's commerce with the East by way of Novgorod was already of much importance, and in 1158 Wisby was declared a free city by the Emperor Lothair. England, France, Holland, Russia, Lubeck, and Rostock had warehouses here; and King Henry III. of England, by a letter dated 1237, granted the merchants of Gothland liberty to trade all over England free from duty. Whilst a member of the famous Hanseatic League, her wealth grew almost fabulously, and the maritime code (Waterrecht, Water-right) of Wisby, framed in the twelfth century, has served as a model of all the navigation laws of Europe. The valuable and yearly recurring finds of Oriental coins" (chiefly Cufic, so named from the character of Arabic writing on them, which is so named after the city of Cufa, where the coins of the early Caliphate at Baghdad were struck) "and ornaments, as well as of Anglo-Saxon and German coins, bear witness to the former commercial intercourse between the East, England, Denmark, Germany, and this island." In Sweden, and especially in the island of Gothland, such an immense number of these Cufic coins have been found, that in the Stockholm Museum alone, Mr. C. R. Markham tells me, 20,000 have been preserved, minted in about 70 different towns within the former dominions of the Abbasside caliphs. Five-sixths of them were coined by sovereigns of the Samanian dynasty who reigned in Khiva, North Persia, and Transoxiana, from about A.D. 900 to 990. A great mass of Eastern ornaments has also been found. There are numerous hints in the Sagas of this Eastern trade, the line of which was from Khiva (Karwezin,) round the north of the Caspian, and up the Volga, to Novgorod, and thence across Russia to the Baltic. It would seem that silver first came to Scandinavia by this route. There was an early distinction between the Easterling or Vandalic Hanse towns (*civitates Sclavicæ*,) of which Lubeck was the chief, and the westerling or Teutonic Hanse towns, of which the capital was Cologne. As the trade with Venice and Genoa increased, the Hanse merchants began to resort to the harbour of Sluys, as the port of Bruges, for the purpose of exchanging the iron, copper, flax, hemp, and timber of the Baltic countries for the spices, drugs, and silks of the East, and the dried fruits and wines of southern Europe. Thither also the English took their tin, lead, hides, rabbit skins, and wool; and thus Bruges became in the 13th century A.D. the entrepôt for the trade of England and the Baltic, and Mediterranean Seas, and the universal mart of Europe, and so remained for nearly 300 years. Bruges was, indeed, the first of the four great comptoirs established by the Hanseatic League, the second being London, the other two Bergen and Novgorod. In London, the office of the League, "Guildhala Teutonicorum," commonly called the "Steel-yard,"* *i.e.*, Stafle-Hoff, or warehouse, was

* The derivation usually given is from *Statera Romana*.

in Thames-street, and it had other Steel-yards at Boston and Lynn. With the fall of Constantinople, and the extension of the Ottoman dominion in Syria and Egypt, the commerce of Bruges suffered proportionally with that of Genoa and Venice; and it suffered further also from the war, begun in 1482, between the Flemings and the Archduke Maximilian, which gradually drove its merchants to Antwerp. The merchandise of India and the East also reached Southern Germany, through Milan, the common depôt of the Venetians and Genoese, and across the Alps to Augsburg and Nurenberg; and during the hostile rivalry of Genoa and Venice many of the German towns opened direct communications with Constantinople, through which the whole of central Europe was supplied with Eastern produce, by Belgrade, Vienna, Ratisbon, Nuremberg, Ulm, Augsburg, and other cities on the Danube. This trade was carried on until the subjugation of Servia by the Turks, A.D. 1459.

The destructive conquests of the Ottoman Turks made the nations of Europe aware of the precarious tenure by which their overland trade with India was held, and at the same time they felt that its freedom from interruption was essential to the progress of civilisation in Europe. It was these considerations which now began to turn the thoughts of the people of Christendom, towards the circumnavigation of Africa, and even led them to hope from the victorious career of Chingiz Khan (*b.* A.D. 1163, *d.* A.D. 1227) and Tamerlane (*b.* A.D. 1335, *d.* A.D. 1405) that an understanding with the Tartars might further their aims of a settled commerce with the East. The first European missions into "Grand Tartary," or "India Major" as it was sometimes called, were indeed sent in the hope of staying the further westward advance of the Tartars. After the successive irruptions of the Goths, Vandals, Huns, Avars, Sclavs, and Turks, which had burst upon Europe from the East, it might have been hoped that the surplus population of Central Asia was exhausted, and that Europe would at last enjoy a prolonged period of peace and prosperity. But this expectation was cruelly dispelled by the overwhelming irruption of the Tartars in the thirteenth century under Chingiz Khan, whose son, Octai or Okkadai, pushed his ravages so far as Poland and the confines of Germany. Batou, a grandson of Chingiz, overran and made conquest of all south-eastern Russia. Also, while Octai was attacking the Eastern frontiers of Europe, the Tartars were, by their advances through Persia and on Bagdad, threatening the possessions which the Crusaders had wrested from the Saracens in the Holy Land. Pope Clement IV., as the Spiritual Father of Christendom, felt, therefore, called upon to make an effort to deliver it from the destruction with which it was imminently threatened; and accordingly the Franciscan friar, Nicholas Ascelinus, was sent, A.D. 1245, to the Tartar camp in Persia, by way of the Holy Land, and Johannes Carpini, another Franciscan, to the Tartar camp, on the Volga, A.D. 1247. Carpini travelled through Bohemia, Silesia, and Poland, and on through the vast regions then known under the name of Coumania, watered by the Dneiper, the Don, the Volga, and the Yaik, and now as the country of the Don Cossacks, until he at last came to the standing camp of "Duke Bathy" (Batou), which afterwards grew into the city of Sarai or Sara, on the Volga. From here he was sent on to the Imperial Court, where he arrived by way of Lake Balkash at the moment when "Cuyne" (misprint for Cuyuc or Kayuk) was being elected to the Great Khanship of the Tartars, in succession to his father, Octai or Okkodai Khan. On his return journey, passing rapidly through the camps of "Duke Bathy" and "Duke Corrensa," who guarded the Tartar frontier in Europe from the nations of the West, he reached Kiev in Russia within eight months of leaving the Imperial Court of Kuyuk Khan. He is the first traveller into Mongolia whose narrative we possess.

While St Louis of France was engaged in the seventh crusade, A.D. 1248-50, and the lieutenant of Octai or Okkodai Khan were at the same time attacking the Saracens from the side of Persia, the Tartars and the Crusaders became united in a common interest. To cement their connection, the general who commanded the Tartar forces in Persia sent an embassy to the French king, expressing the respect he felt for Christianity, and recommending that they should make common cause against their Saracen enemies. An embassy was at once sent into Persia; and at the same time the pious St. Louis, anxious to lose no opportunity, sent the Minorite Friar, William de Rubruquis, on his celebrated mission, A.D. 1253-56, to the Tartar chief "Sartash," whose territories bordered on the Black Sea. From Constantinople, Rubruquis sailed to Soldaia in the Crimea, one of the entrepôts at that time of the Black Sea trade in Russian furs and Indian spices, drugs, and silks, through Constantinople, with the rest of Europe; and thence he journeyed northward through the before-mentioned region of Comania, until he came to the camp of Sartash (Saetak), by whom he was sent on to the Court of his father, Batou, at Sara or Saria. Here he was furnished with a guide to the Court of Mangu, who had succeeded his cousin Kuyuk as Kakhan at Kara Korum, at the easternmost verge of the great Mongolian desert. From the Mongol capital he returned to the Court of Batou on the Volga, and thence to Europe, not by the Crimea, but over the Caucasus, through the country of the Lesgi (Lesghis) and Cargines (Georgians,) Armenia, and Iconium, where he had an interview with the Ottoman Sultan, and by the Cilician port of Carcum to Cyprus, where at Nicosia he found his provincial. Colonel Yule, in his introduction to "The Book of Ser Marco Polo," observes of the Cilician ports at this period (*circa* A.D. 1260), "Alexandria was still largely frequented in the intervals of war as the great emporium of Indian wares; but the facilities afforded by the Mongol conquerors, who held the whole tract from the Persian Gulf to the shores of the Caspian and of the Black Sea, or nearly so, were beginning to give a great advantage to the caravan routes which debouched at the ports of Cilician Armenia in the Mediterranean, and at Trebizond on the Euxine." Rubruquis described Turkey at this time as having "no treasure, few warriors, and many enemies." He also strongly deprecated the system of sending poor religious folk like himself as ambassadors to the Great Khan, without office, presents, or any of the things that command favour or respect of the profane.

After these friars come the merchants of the Polo family. In the year 1266, Nicolas and Maffeo Polo, the father and uncle of Marco Nolo, were at Constantinople, whither they had gone from Veniee with their merchants' wares. Taking counsel together, and having laid in a store of jewels, they resolved to eross "the Greater Sea" (Black Sea), on a venture of trade, to Soldaia. Having staid there a while, they thought it well to extend their journey further, "and travelled until they came to the Court of a certain Tartar Prince, Barca Kaan (a brother of Batou Khan), whose residences were at Sara and Bolgara." While here a great war broke out between "Barca and Alau (Barka's cousin Hulaku Khan), the Lord of the Tartars of the Levant," and in the end "Barea, the Lord of the Ponent," was defeated, and so the two brothers Maffeo and Nicolo could not get baek to Venice by the way they had come, nor until they had gone "across the whole longitude of Asia." Leaving Bolgara they went on to "Ucaca," and thence departing "and passing the great River Tigris" (Volga), traversed a desert country for 17 days until they came to "Bocara." "Whilst they were sojourning in that city there came from Alau, Lord of the Levant, envoys on their way to the Court of the Great Kaan (Mangu Khan, brother of Hulaku), Lord of all the Tartars in the world." At their request the two brothers joined their party, and journeyed a whole year until they reached the Court of the Kublai Khan, who had now sueceeded his brother Mangu as Kakhan of the Tartars. Before the death of Mangu Khan, A.D. 1259, it had been intended to remove the seat of the Tartar eapital from Karakorum into Cathay or Northern China; but this step, which in the end eonverted the Tartar Khan into a Chinese Emperor, was left to be carried out by Kublai Khan. The two brothers were received with great honour and hospitality by Kublai Khan, and when the time came for them to go back to Europe, he charged them with a letter to the Pope, in which he begged that 100 persons of the Christian faith might be sent to him aequainted with "the Seven Arts," ably clearly to prove that "the Law of Christ" was best, which, if they did, he deelared that he and all under him would become Christians. And Kublai Khan delivered into their hands a golden tablet as a passport, by showing which they were honourably provided with whatever they wanted, whithersoever they went. So the two brothers travelled back, westward, on and on, until after three years had come and gone, they at last came to "Leyas in Hermenia," a port on the Gulf of Seanderoon, which was then "one of the chief plaees for the shipment of Asiatic wares arriving through Tabriz, and was mueh frequented by vessels of the Italian Republic." (Yule, Marco Polo, note to Chap. VIII. of Prol.) They reached Acre in April, 1269, when, hearing that Clement IV. was dead, they returned to Venice, there to await the end of the long interregnum which followed his death. When Gregory X. was elected Pope, they at onee started on their second journey to the Court of Kublai Khan, about November, 1271, this time taking young Marco Polo with them. From Acre they proceeded by Leyas and Sivas, and then by Mardin, Mosul, and Bagdad, to Ormuz, at the mouth of the Persian Gulf, hoping to go on to China by sea. This they were not able to do, and so, turning their faces landward, they traversed successively Kerman and Khorassan, Balk, and Badakshan, whence they ascended the upper Oxus to the Pamere plateau, "a route not known to have been since followed by any European traveller except Benedict Goes (1602-1607), until the spirited expedition of Captain John Wood, of the Indian Navy, in 1838." (Yule, Marco Polo, Introduction.) Crossing "the steppe of high Pamere," the travellers proceeded by Kashgar, Yarkand, and Khoten, and the vieinity of Lake Lob, through the Gobi desert to Tangut, until at length, some time durfng the Midsummer of 1275, they arrived at the stately pleasure dome of Kublai Khan in Xanadu. They afterwards proceeded with the Kakhan to the eapital, Cambalu, now Peking. They rose rapidly in the great Kakhan's favour. Young Marco was entrusted with several missions in different parts of the Empire; while to all the hints of the Venetian merchants to be allowed to return home with their gathered wealth, "the aged Emperor growled refusal;" and, adds Col. Yule, "but for a happy chance we should have lost our mediæval Herodotus."

Hulaku Khan, the founder of the Mongol dynasty of Persia ("Lord of the Levant"), was succeeded by his son, Abaka, who married a daughter of the Greek Emperor, Michael Palæologus, and died a Christian. His brother Nicholas, who succeeded him, beeame a Mahommedan, but his son, Arghun Khan, was hostile to the Mahommedans, and almost a Christian. He at least sent embassies (eondueted by a Genoese, named Bascarelli), to the Pope, and the Kings of France and England, proposing an alliance against the Saracens and Turks; and in 1290, Edward the First sent Geoffrey de Langley on a mission to him. Arghun Khan, having lost his favourite wife in 1286, sent to Kublai Khan to select another for him, and about the very time that Geoffrey de Langley's mission was setting out for England, the Polos were commissioned by Kublai Khan to escort the new bride he had ehosen for his great nephew from "far Cathay," by sea, to the Persian Court.

The bridal party sailed from the port of Zayton in the spring of 1292. In the April following they would be in Sumatra, where they probably remained until September, when, passing through the Straits of Malacca they touched at Ceylon, at an Indian port on the Coromandel coast, at Kayal, and other ports of the Malabar and Concan coasts of Western India, at one of which, Kayal or Tannah, they passed the monsoon of 1293. Marco Polo notices the fine cottons of Coromandel, and the abundance of pepper and ginger of Malabar, the ineense of Tannah, and the pepper, ginger, indigo, and cotton of Guzerat. Sailing on the close of the monsoon, from Tannah or Kayal, the party reached Ormuz about November, 1293, and the Persian camp two months later. Here the fair princess wept as she took leave of the three Polos, who went on to Tabriz, and, after a long halt there, proceeded towards Veniee, where they arrived some time in 1295, having been absent from home nearly twenty-four years. The publication of the book of Ser Mareo Polo was as the revelation of a new world, and excited the imagination of Europe as highly as the discovery of America by Christopher

Columbus. It is also a perfect Encyclopædia of the mediæval trade and arts of India and the East —a book like the Bible, Homer's epics, the History of Herodotus, and Pliny's Natural History, of which one never tires, which is always fresh—and yet we owe its existence to the accident of its author having late in life been taken in a sea-fight by the Genoese, and thrown for four years into prison, where he dictated it to relieve the tedium of captivity. From the time of the Saracen conquest of Egypt, Syria, and Persia, Christians had been forbidden to pass through those countries to the East, and the direct overland trade of Europe with India had entirely ceased. Marco Polo, therefore, was the first Christian, after Cosmas Indicopleustes (*circa* A.D. 535-50), to visit India, and all the people of Europe were astonished at the survey of the immense countries, beyond what they had thought the uttermost bounds of the eastern world, which he for the first time laid open to their view, and, it was hoped, to their commercial enterprise. The principal ports on the Eastern Seas described by Marco Polo are "Kinsay" (Hangchau-fu), "Zayton" (Chinchau), "Maliaur" (corresponding with Malacca), "Cail" (Kayal), "Coilum" (Quilon), "Tana" (Tannah), "Cambaet" (Cambay), "Zanghibar" (Zanzibar), "Hormos" (Hormuz), "Kisi" (Kish), and Aden.

Marino Santo, a Venetian nobleman, who travelled in the East about 1300-1306, in his pamphlet entitled, "Liber secretorum fidelium Crucis, super Terræ Sanctæ recuperatione," presented to Pope John XXII. at Avignon, initiates us into all the details of the course of the Venetian commerce with India at this period. Formerly, and even down to his own time, it used to take the route by the Persian Gulf. The merchandise of Malabar and Cambay was first conveyed to Ormus and Kish, on the Persian Gulf, and was thence transported to Bussorah on the Euphrates, whence it passed up the Tigris to "Baldac" (Baghdad), and across the Syrian desert to Antioch and Licia, where it was embarked for Europe on board the ships of Genoa and Venice. Latterly, however, the merchants of Southern Arabia had gradually recovered their old commerce, and part of the merchandise of India and the East now came into Europe by way of 'Ahaden (Aden), and "Chus" (Coptos) on the Nile, and Alexandria. The rarer commodities, such as cloves. nutmegs, mace, gems, and pearls, were still conveyed by the Persian Gulf to Bussorah, and thence to Baghdad, from which they were carried to some port on the Syrian or Arabian coast of the Mediterranean; but all the more bulky goods, such as pepper, ginger, cinnamon, together with a portion of the more valuable articles, were now re-conveyed by the ancient route up the Red Sea, and across the Libyan desert, and down the Nile to Alexandria.

There is very little information directly bearing on the subject of this paper to be derived from the letters and reports of the missionary friars of the fourteenth century, published by Colonel Yule in his "Cathay and the Way Thither"; viz., the letters of the Franciscan Friar, John of Montecorvino (b. 1247; d. 1328), which are dated from "Cambale" (Pekin) the 8th January, 1305, and February, 1306; of Andrew of Perugia, of the Order of Minorite Friars, Bishop of Zayton, in Manzi (Southern China) dated Zayton, January, 1326; of the Dominican Friar Jordanus, dated from Tannah, near Bombay, January, 1323; and of the Franciscan Friar, Pascal of Vittoria, whose letter is dated from "Armalec" (Almalik, or "Old Kulja)" in the Empire of the Medes," on the feast of St. Laurence, 1338;" and "the Book of the Estate of the Great Caan" set forth by the Archbishop of Soltania (the Dominican Friar, John de Cora) *circa* 1330. In the letter from the Dominican Friar Menentillus, forwarding the copy of a letter from Friar John of Montecorvine, among the products of "Upper India," he enumerates aromatic spices, pepper, ginger, brazil wood, and cinnamon, and he also refers to cane sugar, date sugar, and arak.

The famous Minorite Friar, Odorico de Pordeonne (b. 1281, d. 1331), a Beatus of the Roman Catholic Church, travelled in the East and in India between 1316 and 1330. He proceeded by way of Constantinople and Trebizond, "Arziron" (Erzeroum), Tauris, "Soldania" (Sultanieh) and "Cassan" (Kashan), "Iest" (Yezd), and the "sea of Sand" and ruins of "Comerum" (Persepolis), and the kingdom of "Chaldæa" (Baghdad) to "Ormes" (Ormuz), where he took ship to Tanna in Salrette, near Bombay. Here, or at Surat, where Friar Jordanus had deposited them, he gathered the bones of the four missionaries who had suffered martyrdom there in 1321, and took ship again to "Columbum," or "Polumbum" (Quilon). He notes the immense quantity of pepper cultivated in "Minibar" (Malabar), on which coast he also visited the towns of "Flandrina" (Pandarani) and "Cycilin" (Cranganore). He then went on to "Mobar" (the Coromandel coast), and thence in fifty days sailed to "Lamori" (Lambri) in the kingdom of "Sumoltra" (Sumatra). From Sumatra he went on to Java, and another island called "Thalamasyn" or "Panten," which has been thought to be Borneo, and thence to "Zampa" (Cochin China). He next noticed the island of "Nicoveran" (Nicobars), and of "Sillan" (Ceylon), whence his narrative carries us at once to "Upper India" (China), and the province of "Manzi" (Southern China), and the cities of "Censcalan" (Canton), "Zayton" (Chinchau), "Fuzo" (Fouchu), "Cansay" (Hangchau), "Chileufu" (Nanking), and "Cambaleth" (Pekin), and "Saudu" (Xanada), the summer residence of the Great Khan. He describes the county of Prester John and Thibet, and the Grand Lama as the Pope of that country. He also gives an account of the "Old Man of the Mountains," and the "Devils of Tartary." He was preparing to set out a second time to travel through the East, when he died at Pisa in 1331.

John de Marignolli, a Minorite Friar of the Franciscan Monastery of Santa Croce at Florence, was sent by Pope Benedict on a mission to Cathay in 1338. He sailed from Avignon to Naples, and thence to Constantinople, and on to Caffa (Theodosia) in the Crimea, whence he proceeded to the Court of the Khan of Kipchak at Sarai on the Volga, who forwarded him on to Armalec (Almalik), the capital of the Chagatai Khans of the "Middle Tartar Empire." He arrived at Cambalec (Pekin) in May or June 1342, and after remaining there three or four years, sailed from Zayton for India, the 26th December, 1347,

and arrived at Columbum (Quilon) the following Easter. In 1349 he made a pilgrimage to the Shrine of St. Thomas on the Coromandel coast; and thence proceeded to "Saba," which he piously identified with the Sheba of the Bible, but which was probably Java, or, Colonel Yule would suggest, some province of Sumatra. Sailing back to Malabar, he was driven to Ceylon, whence he sailed to Ormuz, and afterwards travelled by the ruins of Babylon to Baghdad, Mosul, Odessa, Aleppo, and thence to Damascus, Galilee and Jerusalem, making his way back to Italy by Cyprus.

Sir John Mandeville, the author of, it is said, the first English book that appeared in print (London, 1499), would appear, from his narrative, to have traversed the whole of the East between 1327 and 1372, the date of his death. He speaks of the marvels of Inde, but it is hard to say if he was ever there. He may be described as the father of sensation writers, and is not to be trusted, even when he may be telling the truth.

During the latter half of the fourteenth century, Tamerlane, taking advantage of the dissensions among the descendants of Chingiz Khan, succeeded in once again uniting the nomad hordes of Central Asia in a career of universal devastation. He was proclaimed Khan of Chagatai, and made Samarcand his capital in 1369. He overran Persia in 1386-87, and Kipchak several times between 1387 and 1389, in the latter year reaching so far as Moscow. He took Baghdad in 1395, invaded India and stormed Delhi in 1398, invaded Asia Minor and Syria in 1400-1401, and defeated and captured the Emperor Bajazet at the great battle of Angora, July 20th, 1404. Tamerlane's triumphant war against the Ottoman Turks quickly drew the princes of Christendom into relations with him. In 1393, Henry III. of Castile sent two noble knights, named Pelayo de Sotomayor and Fernando de Palazuelos, on an embassy to his camp. They were received with distinction, and were present at the battle of Angora, and Tamerlane sent an envoy of his own with them on their return to Spain, with rich presents for the King of Castile, of jewels and women, among whom were two lovely Christian damsels, named Angelina and Maria, who had been rescued from the seraglio of the brutal Bajazet. King Henry therefore determined to send another embassy to Tamerlane, at the head of which was Don Ruy Gonzales de Clavijo, whose narrative of it is one of the earliest Spanish works of authentic travel. It is of the highest interest, not only for the account it gives of Tamerlane, but for the light it throws on the caravan trade of the period through Persia; but it was not until 1869 that an English translation of it, made by Mr. Clements Markham for the Hakluyt Society, was published, although an earlier MS. translation of it, by Lord Valentia, is said to exist. Accompanied by the returning Tartar envoy, Clavijo embarked at the port of St. Mary, near Cadiz, in May, 1403, and sailed through the Strait of Bonifacio to Gaeta, from which he continued his course through the Strait of Messina to Rhodes. Here he hired a ship to Chios, where he engaged another to Constantinople. Sailing through the "Strait of Romania" (the Dardanelles) he saw on one side "the land of Turkey," and on the other "the land of Græcia." He left Constantinople on the 14th of November, passing in the Bosphorus between two castles, one being named "*el Guirol de la Græcia*," and the other "*el Guirol de la Turquia*." Disembarking at Trebizond, he proceeded by "Arsinga" (Erzingham) and "Aseron" (Erzeroum), through Armenia, and across the "Corras" (Cyrus) to Taurus, or Tabreez, and Sultanieh in Azerbijan. The latter city, which is now a mere mass of ruins, he represents as then very populous, but not so large as Tabreez, although it had more trade. Every year, in the months of June, July, and August, large caravans came there from India with spices, "such as cloves, nutmegs, cinnamon, manna, mace, and other precious articles which do not go to Alexandria;" and from Ghilan with wrought silk, to be sent to Damascus, Syria, and Turkey; and merchants came there for silks from all countries, "even Venetians and Genoese." Silken stuffs, cottons, and taffetas also came to Sultanieh from Shiraz and "Yessen" (Yezd), and cotton threads and cotton cloths from Khorassan. "From Cathay vessels came within 60 days' journey of this city, having navigated the western sea . . . and they came to a river (Minav) which is 10 days' journey from the city of Ormuz." . . . . . These ships brought pearls and rubies from Ceylon (not from Cathay, as Clavijo was told), and spices from India. "All the merchants who come from the land of the Christians, from Caffa (Theodosia) and Trebizond, and the merchants of Turkey and Syria, come every year at this time (June 1404) to the city of Sultanieh to make their purchases." From Sultanieh the embassy proceeded through Mazanderan, by Teheran, to Dhamghan in Khorassan, and by Nishapore, where Clavijo notices the "torquoisos," to "Ojajan," where they received a message from Shah Rokh, Tamerlane's celebrated youngest son, inviting them to Herat. From Ojajan they went on to "Maxaque" (Meshed) and "Buelo," after which they had to cross a desert of 50 leagues, at the end of which they found themselves in "the land of Tartary." They now crossed the "Morghan" (Moorghob), and after passing through "Vaeq" (Balk), "the great river Viadme" (the Oxus), "another of the rivers of Paradise . . . which descends from the mountains, and flows through the plains of the territory of Samarcand . . . and falls into the sea of Bakou" (the Caspian). Then, after travelling for several days, they came to the formidable pass of the "Iron Gates," in the mountain chain that guards Tartary "in the direction of India," and going on to Quex (Kesh), the birthplace of Tamerlane, entered his beautiful capital of Samarcand, September 8th, 1404. But Clavijo never saw him. The mighty destroyer was then dying. After being most hospitably entertained, the embassy departed on its return journey on the 21st of November, and on reaching Tabreez received the intelligence of Tamerlane's death, which took place at Otrar on the Jaxartes, February 19th, 1405. From Trebizond Clavijo took ship for Pera, where he found two Genoese carracks, which had come from Caffa, and were going to Genoa. He took his passage in one of them, which, after stopping at Gallipoli to take in a cargo of cotton, and at Chios, and Gaeta, and at Corsica, "to spend Christmas-day," reached Genoa, January 3rd, 1406. He himself reached Seville the following March.

In 1419, Shah Rukh sent Sadi Khoja on an embassy into China, and in 1442, sent Abdul-er-Razzak on an embassy to India. Abdul-er-Razzak set out from Herat in January, 1442, and proceeded by way of Kohistan and Kerman to Ormuz. He thus describes this port:—"The merchants of the seven climates, from Egypt, Syria, Roum (Anatolia), Azerbian, Irak-Arabi, and Irak-Adjemi, the provinces of Fars, Khorassan, Marwaraamahar (Transoxiana), the kingdom of the kingdom of Kipchak, the whole of the kingdoms of Tchin (China or Cathay) and Matchin (Manzi or Southern China), and the city of Khanbalik (Pekin), all make their way to this port, which has not its equal on the surface of the globe. The inhabitants of the sea coasts arrive here from the countries of Tchin, Java, Bengal, the cities of Zirbad (*India extra Gangem*), Tenasserim, Sokotora (Socotra), Schahrinou (Sivanur), the islands of Diwah-Mahal (Maldives), the countries of Malabar, Abyssinia, Zanguebar, the ports of Bijanagar, Kalbergah, Guzrat, Kanbait (Cambay), the coasts of Arabia, which extend so far as Aden, Jeddah, and Yembo. They bring hither those rare and beautiful articles which the sun, the moon, and the rains have combined to bring into perfection. . . . Travellers from all countries resort hither, and in exchange for the commodities which they bring, they can, without trouble or difficulty, obtain all that they desire. . . . For all objects, with the exception of gold and silver, a tenth of their value is paid by way of duty. Persons of all religions, and even idolaters, are found in this city, and no injustice is permitted towards any person whatever." From Ormuz, after two months' sojourn, Abdul-er-Razzak sailed for Calicut, but, being too late for the S.W. monsoon, was compelled to pass several months at Muscat. He landed at Calicut at the beginning of November, 1442, and remained there until the middle of April, 1443. He describes it as "a perfectly secure harbour, which, like that of Ormuz, brings together merchants from every city and from every country. "In it are to be found abundance of precious articles, brought thither from maritime countries, especially from Abyssinia, Zirbad, and Zanguebar. From time to time ships arrive there from the shores of the House of God (Mecca) and other parts of the Hedjaz, and abide at will for a greater or longer space in the harbour. The town is inhabited by infidels, and situated on a hostile shore. . . . The sovereign of the city bears the title of *Sameri*. . . . The coast, which includes Calicut and some neighbouring ports, and which extends as far as Kabel, a place situated opposite the island of Serendib, otherwise called Ceylon, bears the general name of Meliber (Malabar). From Calicut are vessels continually sailing for Mecca, which are for the most part laden with pepper. The inhabitants of Calicut are adventurous sailors; they are known by the name of *Schini-betchegan*, "sons of the Chinese," and pirates do not dare to attack the vessels of Calicut. In this harbour one may find everything that can be desired. One thing only is forbidden, namely, to kill a cow or to eat its flesh." From Calicut he went on by sea to Mangalore, "which forms the frontier of the kingdom of Bijanagar," from which port he continued his route by land to the city of Bijanagar, which he reached by the end of April. He gives a graphic account of the magnificence of this ancient Hindu city, where he was entertained in the most princely state by the King until the following November, when he returned to Mangalore. Going on to "Honawar" (Onore) he there took his passage to Ormuz, which port he reached April 22, 1444,—the voyage from Onore to Ormuz having lasted 65 days.

Nicolo Conti, a noble Venetian, travelled in India and the East for 25 years, between 1419 and 1444. Having, in 1449, sought absolution from Eugene IV. from the sin of denying Christ on the borders of Egypt, in order to save his wife and children, who had accompanied him in all his peregrinations, from death, that Pope imposed on him the gentle penance of relating his adventures to his secretary, the famous scholar Bracciolini Poggio, the immortal author of the "*Facetiæ.*" Conti sailed from Damascus, where he had resided for some years, and had learned the Arabic language; and, travelling in company of a caravan of 600 other merchants, passed over the deserts of Arabia Petræa, and through Chaldæa to "Baldochia" (Baghdad). Sailing thence down the river Euphrates for 20 days, he arrived at "Balsera" (Bussorah), and four days after at the head of the Persian Gulf, and in five days more at the port of Colcus, and afterwards at Ormuz. Sailing thence towards India he arrived after 100 miles at "Calcatia," a very noble emporium of the Persians. Here he stayed some time and learned the Persian language, when he and some Persian merchants freighted a ship to India, "having first taken a solemn oath to be faithful and loyal companions one to another." At the end of a month at sea they arrived at Cambay, where, he observes, "are those precious stones, sardonixes." Proceeding southward along the coast of Western India, Conti, after 20 days' sailing, arrived at two cities on the seashore, "one named Pacamuria, and the other Helly." In these districts he says "grows ginger, called in the language of the country *beledi*, *gebeli* and *neli*." Departing thence, and travelling for about 300 miles inland, he arrived "at the great city of Bizengalia" (Bijanagar). Eight days' journey from it he came to "the very noble city of "Pelagonda," and in twenty days more to the seaport of "Pcudifetania" (some port on the Coromandel coast?), "on the road to which he passed two cities, viz., Odeschiria and Cenderghiria (Chandgerry in the Carnatic?) where the red sandal wood grows." He next arrived at "Malepur" (Maliapur, *i.e.*, the city of Peacocks or St. Thome), "where the body of St. Thomas lies honourably buried;" "beyond which," he says, "is another city, called Cahila Kail, where pearls are found." He then crossed over to "a very noble island called Zeilam (Ceylon) . . . in which they find, by digging, rubies, saffires, garnets, and those stones which are called cats' eyes. Here also cinnamon grows in great abundance." He afterwards went on to "the island of Taprobana, which island is called by the natives Sciamuthera (Sumatra, which is called also Taprobana, the ancient name of Ceylon, by others beside Conti), where he remained a year, and where he notices the pepper, long pepper, camphor, gold, and *duriano* (*Durio Zebethinus*)." Leaving Sumatra, he arrived, after a stormy passage of 16

comes from India Major, from a city called Bangchella (Bengal), a very large quantity of stuffs of cotton and of silk." It was there that he first heard of the arrival of the Portugese, by the Cape of Good Hope, in the east, from a Moor who traded with Venice and Genoa, and who complained bitterly of articles of merchandise not arriving at Mecca as usual, and of the King of Portugal as the cause, "he being Lord of the Mare Oceano (Atlantic) and of the Persian and Arabian Gulfs." From Zida (Jiddah), the port of Mecca, he took ship and went on to "Chameran" (Camran, an island off the coast of Yemen) and Gezan (Jeezan, a city of Yemen) and Aden, "the strongest city that was ever seen on the level ground. It has walls on two sides, and on the other sides there are very large mountains. On these mountains there are five castles, and the land is level, and contains about 5,000 or 6,000 families. . . . . This city is extremely beautiful. . . . It is the rendezvous of all the ships which come from India Major and Minor, from Ethiopia, and from Persia. All the ships that are bound for Mecca put in here." Here Varthema again heard of the Portugese. The year before his arrival at Aden some Portugese ships had made their appearance in the sea between India and Ormuz, and seized seven Arab ships, and murdered most of the crews; and while Varthema was at Aden "there ran to the palace forty or sixty Moors belonging to two or three ships which had been captured by the Portuguese, and who had escaped by swimming," and they denounced Varthema as a Portuguese spy. On this the city rose in a tumult, and demanded to slay him. But the Sultan's officers interposed, and sent him to the Sultan at Rhada, by whom he was thrown into prison. Being liberated at the suit of the Sultana, and having further freed himself of her blandishments, he obtained at Aden a passage on board a ship going to India, which was to touch at a port in Persia. But on the seventh day of the voyage his ship was driven into the African port of Teila, "together with 25 ships laden with madder to dye cloths; for every year they lade as many as 25 ships in Aden with it. This madder grows in Arabia Felix (Yemen)." The city of Zeila he describes as "a place of immense traffic, especially in gold and elephants' teeth. Here, also, are sold a great number of slaves . . . . . . and from this place they are carried into Persia, Arabia Felix, and to Mecca, Cairo, and into India . . . . . . Much grain grows here, and much animal food, and oil in great quantity, made, not from olives, but from *zerzalino* (ingeniously and rightly identified by Badger with *juljulan* or *jinjili* —(*Sesamum orientale*), money and wax in great abundance." As soon as the weather became favourable, he set sail and arrived at "Barbara" (Berbera), and in 12 days more (being apparently unable to make the Persian Gulf) arrived at "Diubandierrumi" (*i.e.*, Diu Bander-er-Rumi, Diu, the port of the Turks). "There is an immense trade in this city. Four hundred Turks reside there continually." From Diu he went to "Goa" (Gogo), whence he crossed the Indian Ocean to "Guilfar" in the Persian Gulf, from which he visited "Meschet" (Muscat), and, crossing to the opposite shore of the Persian Gulf, "the noble city of Ormuz, which is extremely beautiful . . . and is the chief, that is, as a maritime place, and for merchandise." From Ormuz he proceeded by land to "a city called Eri (Herat), and the country is called Corazani (Khorassan), which would be the same as to say 'The Romagna.' The King of Corazani dwells in this city, where there is a great plenty, and an abundance of stuffs, and especially of silk, so that in one day you can purchase here 3,000 or 4,000 camel loads of silk. The district is most abundant in articles of food, and there is also a great market for rhubarb . . . . I quitted this place, and travelled twenty days on the mainland, finding cities and castles very well peopled." He returned to Ormuz by way of "Schirazo" (Shiraz), where he notes the "great abundance of jewels, that is, of turquoises, and an infinite quantity of Balan rubies . . . from a city which is called Balachsam (Badakshan). And in the said city there is a large quantity of ultramarine, and *tucia* (*tutya*, antimony, used in the preparation of *kohl*, the powder with which Eastern beauties smear their eyelids), and musk." From Shiraz he made, with a Persian merchant, an abortive attempt to reach "Sambragante" (Samarcand), failing in which he went back to Ormuz, and there embarked on board a ship, which in eight days arrived at the port of "Cheo" (Kow) in the Indies, whence he sailed on to Combeia" (Cambay), "a most excellent city, abounding in grain and very good fruits. In this district there are eight or nine kinds of small spices, that is to say, *turbidi* (turbeth), *gallanga* (galangale), *spiconarda* (spikenard), *saphetica* (assafœtida), and *lacra* (?), and other spices, the names of which I do not remember. An immense quantity of cotton is produced here, so that every year 40 or 50 vessels are laden with silk stuffs, which stuffs are carried into different countries. In this kingdom of Combeia also, about six days' journey, there is a mountain whence cornelians are extracted, and the mountains of chalcedonies. Nine days' journey from Combeia there is another mountain, in which diamonds (this is probably a vague reference to the mines of Golconda) are found. . . . It is impossible to describe the commerce of the country. About 300 ships of different countries come and go here. This city, and another of which I will speak in the proper season, supply all Persia, Tartary, Turkey, Syria, Barbary, that is Africa, Arabia Felix, Æthiopia, India, and a multitude of inhabited islands, with silk and cotton stuffs."

Departing from Cambay, Varthema, after 12 days' voyage, arrived at "Cevul" (Chaoul). "It possesses an extremely beautiful river, by which a very great number of foreign vessels go and return, because the country abounds in everything, excepting grapes, nuts, and chestnuts. They collect here an immense quantity of grain, of barley (impossible), and of vegetables of every description; and cotton stuffs are manufactured here in great abundance. . . . There are in this city a very great number of Moorish merchants." In two days' voyage from Chaoul he came to "Dabuli" (Dabul), where, he notices, were Moorish merchants "in very great numbers;" and thence he sailed on to Goga (Goa), from which place he proceeded inland, and after seven days arrived at "a city which is called Decan" (Bijapur, the metropolis of the Mahommedan kingdom

of the Deccan). Returning to the coast in five days, he reached the port of "Bathacala" (Beitkul, Sadaseoghur, or Carwar). He observes, "there are many Moorish merchants here, for it is a place of great traffic." He also visited the island of "Anzediva" (Anjidiva), "distant from the mainland half a mile," and "travelling for one day from the aforesaid island," arrived at "Centacola" (Ancola), and in two days more at "Onor," and afterwards at "Mangalor" and "Cananor." "Here we begin to find a few spices, such as pepper, ginger, cardamums, mirabolans, and a little cassea." Having spent some days here, Varthema started on another journey up country "towards the kingdom of Narsinga, and travelled on the mainland for 15 days towards the East (N.E. by N.), and came to a city called 'Bisinegar' (Bijanagar), . . . a place of great merchandise, and is endowed with all possible kinds of delicacies." Returning to Cananore he went on, by way of "Tormapatani" (Dormapatam), and "Pandarani," and "Capogatto" (Kotakul), "to the very noble city of Calicut . . . . the head of India, that is to say . . . the place in which the greatest dignity of India is centred." Wherefore it appears fitting to Varthema at this point of his narrative "to bring the First Book to an end, and commence the Second, which opens with a graphic description of Calicut and of its King, called Samory, which, in the Pagan language, means God on Earth." This is the Zamorin of the Portuguese discoveries of India, a name really signifying Lord of the Sea, a most appropriate title for the King of Calicut. Calicut he describes as situated on the open beach, and "the sea beats against the walls of the houses." Varthema found there merchants from all parts of the East, "very many Moorish merchants, many from Mecca, and part from Banghella (Bengal), some from Ternasseri (Tenasserim), some from Pego (Pegu), very many from Ciormandel (Coromandel), in great abundance from Zailani (Ceylon), not a few from Colon (Quilon), and Caicolon (Kayan Kulam), a very great number from Bathacala (Beitkul), from Dabuli (Dabul), from Chievuli (Chaoul), from Combeia (Cambay), from Guzerati, and from Ormuz. There were also some from Persia and from Arabia Felix, part from Syria, from Turkey, and some from Ethiopia and Oarsinga (Bijanagar, 'the kingdom of Narsinga'). There were merchants from all these realms in my time. It must be known that the Pagans do not navigate much, but it is the Moors who carry the merchandise, for in Calicut there are at least 15,000 Moors, who are for the most part natives of the country. . , . The time of their navigation is this: from Persia to the Cape of Cumerin, which is distant from Calicut eight days' journey by sea towards the south,* you can navigate through eight months in the year; that is say, September to all April; then from the first of May to the middle of August, it is necessary to avoid this coast because the sea is very stormy and tempestuous. . . . At the end of April they depart from the coast of Calicut, and pass the Cape of Cumerin, and enter into another course of navigation, which is safe there four months, and go for small spices;"—that is, go and trade in the Indian Archipelago. He describes the pepper and ginger plants of Calicut at length, aud among the fruit trees of the country mentions the *ciccara* (jack), *camba* or *manga* (mango), *carcopal*, *comalanga*, *malapolanda* (plantain), and *tenga* (cocoanut). He also mentions that a great quantity of sesamum seed ("*zerzalino*") is produced in the country. Varthema's Persian companion, whom he had picked up at Shiraz, not being able to dispose of his merchandise at Calicut, by reason of the confusion caused by the quarrels of the Zamorin with the Portuguese, the two proceeded by river to "Cacolon" (Kayan Kulam), where, he notices, were many "Christians of St. Thomas," and then to "Colon" (Quilon) and "Chayl" (Kayal), where "we saw those pearls fished for in the sea, in the same mauner as I have already described to you in Ormuz." "We then," says Varthema, "passed further onwards, and arrived at a city which is called Cioromandel (Coromandel), which is a marine district, and distant from Colon seven days' journey by sea. . . . I found some Christians in this place, who told me that the body of St. Thomas was 12 miles distant from this place," at Maliapur or St. Thome. "They told me that Christians could not live in that country after the King of Portugal had come there, because the said King had put to death many Moors of that country, which trembled throughout for fear of the Portuguese." He then crossed a gulf of to "Zailon" (Ceylon), where he notices the elephants, rubies, garnets, sapphires, jacinths, and topazes, and two fruits named *melangoli* (oranges) and *carofzoli* (?), and the *canella* or cinnamon tree. From Ceylon he returned to the Coromandal coast, and at "Pallachet" (Pulicat), "a place . . . of immense traffic . . . and especially in jewels" from Ceylon, and Pegu, he took ship to "Tarnassari" (Tenasserim), a thousand miles across the sea, and arrived there in 14 days. "Silk is made there in large quantities. A great deal of Brazil wood is found there, fruits in great abundance, . . . and cats which produce the civet." Thence he took "the route towards the city of Banghella" (Gour, the capital of Bengal). "The Sultan of this place is a Moor, ... and he (like the Bijapur Sultan) is always at war with the King of Narsingha. This country abounds more in grain, flesh of every kind, in great quantity of sugar, also of ginger, and of great abundance of cotton, than any country in the world. And here are the richest merchants I ever met with. Fifty ships are laden every year with cotton and silk stuffs, . . . that is to say, *bairam*, *namone*, *lizati*, *ciontar*, *doazar*, and *sinabaffs* (identified by Badger with *sina-bafta*, 'China-woven' cloths). These same stuffs go through all Turkey, through Syria, through Persia, through Arabia Felix, through Ethiopia, and through all India. There are also here very great merchants in jewels, which come from other countries." Next, he sailed "about a thousand miles" to "Pego" (Pegu), and thence to "Melacha" (Malacca), opposite to which is "a very large island which is called Sumatra." "Melacha pays tribute to the king of Cini (Siam), who caused this place to be built about eighty years ago . . . and truly I believe that more ships arrive here than in any

* The original has a full stop here, but I have ventured to change it to a comma, which makes the meaning of the paragraph perfectly clear.

other place in the world, and especially there come here all sorts of spices, and an immense quantity of other merchandise. . . . A great quantity of sandalwood and tin is found here." From Malacca he paid a visit to Peder, on the island of Sumatra, where "grows a very great quantity of pepper and of long pepper, which is called *molaga*. . . . And you must know that in this port there are laden with it every year eighteen or twenty ships, all of which go to Cathia (China). An immense quantity of silk is produced in this country (?). . . . A great quantity of benzoin is also produced here." He mentions also aloes wood of three sorts, *calampat* (the *Kalambak Aloesaylon Agallochum* of Cochin China), *loban* (gum-benjamin), and *bochor*, as if products of Sumatra, but the true aloes wood is only produced in Cochin China, and *lacca*," the dye-wood of *Tanarius major*, and not *lac*, the source of sealing-wax and lake. Next Varthema accompanied the Persian on a long voyage to the "island of Bandan" (Banda Islands), "where nutmegs and mace grow; and from it visited the island of "Monoch" (the Moluccas), "where the cloves grow;" and the island of Bornei (Borneo); whence they crossed over to "Giava" (Java), and then returned to Malacca. Here his companion bought "5,000 *pardai* worth of small spices, and silk stuffs, and odoriferous things," and with them they sailed away together westward, and arrived again on the Coromandel coast, probably at Negapatam, in 15 days. Here he met 22 Portuguese, the first, it would seem, he had himself fallen in with in India. From Negapatam he went round to Quilon and to Calicut, where he met two Milanese who had come in the Portuguese ships round the Cape of Good Hope to purchase jewels on behalf of the King of Portugal. They had landed at "Cocin" (Cochin), from which place they had deserted from the Portuguese to Calicut, to make cannon for the Zamorin. Making his way to Cannamore, Varthema was employed for some time in the Portuguese service. He was present in the great fight between the Portuguese and Zamorin fleets, A.D. 150 , and was employed for a year and a half as factor at Cochin. Finally, on the 6th of December, 1507, he left Cannamore in the homeward bound ship, *San Vicenzo*. After a course of about 3,000 miles he reached Mozambique, having passed Melinda, Mombasa, Kilwah, Sofala, Pate, and Brava on the way. Then the Cape was rounded, and the *San Vicenzo* passed northward under St. Helena and Ascension, and finally anchored in the Tagus off Lisbon, where he was warmly welcomed by the King, Don Emanuel of Portugal. The high interest of Varthema's travels is that they were undertaken at the very time of the Portuguese discovery of the Cape route to India, and give us a detailed and accurate survey of the commerce of the Eastern seas as it existed at the moment before it was to be completely revolutionised by this great event.

The present of the most rare and costly articles of the Indian trade, made by the Sultan of Egypt, in 1487, to Lorenzo de Medicis, of which Roscoe has published a particular account in the appendix to his life of the illustrious Florentine merchant, affords a vivid idea of its general character between the fall of Constantinople, which ruined the Genoese trade with the East by the Black Sea, and the discovery of the passage to India by the Cape of Good Hope, which gradually undermined the Venetian trade by Alexandria and Famagusta, and at last completely subverted the through overland trade between Europe and Southern Asia.

The consequence of this revolution was greatly aggravated by the Turkish conquest of Syria and Egypt, A.D. 1516-17, and of Cyprus, 1570-1. In Vansleb's "Present State of Egypt," published in 1678, we have the evidence of an eyewitness of the completeness of the ruin of that part of the ancient overland trade between the East which had, previously to Da Gama's successful enterprise, gone by way of Aden and the Red Sea.

THE PORTUGUESE ASIA.

The Portuguese were the first who, after the Phœnicians, explored the South Atlantic coasts of Africa, and doubled the Cape of Good Hope, and they were the first to discover India by this navigation, and to open up to the nations of Europe the sea-way through the Indian Archipelago, and on China and Japan. The gradual advance in Western civilisation began, during the fifteenth and sixteenth centuries, to force on the sovereigns of Europe a more scientific organisation of their administrative and executive powers, the cost of which rapidly grew out of all proportion to the resources derived from the royal demesnes and feudal tenures, which had hitherto sufficed for their maintenance. Hence the encouragement of trade, as the first necessity of national existence, by the enlightened statesmen of this period. The great wealth of Genoa and Venice attracted their attention, particularly to the commerce of India, and the accounts which Marco Polo brought home of the rich Eastern countries through which he had travelled, created the spirit of mercantile discovery and enterprise throughout Europe. As the Turks, succeeding to the Saracens, gained ground in Western Asia, the uncertain and dependent character of the overland trade with India became clearly recognised; and when Constantinople was taken by Mahomet II., and Genoa in consequence lost Pera and Caffa, the whole thought of the people of Southern Europe—and more especially of the ruined Genoese—became fixed on the discovery of the sea-way to India, and establishing direct communications with a country where nature seemed prodigal in the production of everything that could satisfy the luxury of mankind. It was first attempted, as has been shown, to enter into relations with the Tartars, and much was at one time hoped for from an alliance with Prester John, if haply his half mythical kingdom might be found, and at a later period, subsequent to Da Gama's voyage, the Genoese, in the hope of recovering their rapidly failing prosperity, proposed to the Czar of Muscovy a plan for bringing the merchandise of India into Europe, once more overland, through Russia. But it was all in vain. The social and political condition of the age required a broader, securer, and more permanent basis of commerce than the world had yet seen—a universal basis, which the ocean, free to all as the common right of nature, alone could give it. It naturally fell to the Atlantic States of Europe to discover the ocean highway to India, the explora-

tion of which was first systematically undertaken by the Portuguese—a people whose national character had been developed to the highest pitch of courage, energy, and contemporary culture in their long struggle for independence with the Moors, and who in Prince Henry, "the Navigator" (b. 1394, d. 1460) found a leader worthy to direct them in the high adventure. He was the fourth son, of King John the Great, of Portugal, and Queen Philippa his wife, a daughter of "John of Gaunt, time-honoured Lancaster," and a grandson therefore of Edward III. of England. He gained so great a reputation throughout Europe by the capture from the Moors, in 1415, of Ceuta, then the centre of the commerce of Alexandria and Damascus with the west of Africa and Europe, that he was asked by the Greek Emperor Manuel Palœologus to take the command of his armies against the Turks. But his mind had early been attracted "by the treasures of the Arabs, and of rich India;" and, establishing himself at Cape Sagrez (Sacer Promontorium), the extreme south-western corner of Europe, overlooking the mysterious waste of the yet unexplored Atlantic, he there devoted himself to the study of astronomy, navigation, and the elaboration of those plans of maritime discovery which at length laid open to Europe the whole of the Southern Africa, the southern coasts of Asia, and Australasia, in the old world, and the new world of America. It was the revenues of the Order of Christ, of which Prince Henry was the Grand Master, which provided him with the means for carrying out his unbounded projects, in which, it must never be forgotten, his aim was as much the conquest and conversion of the heathen as the extension of the commerce and dominion of Portugal. He had already, in 1412, before the reduction of Ceuta, sent a ship to make discoveries on the coast of Barbary. Cape Nam or Non, *i.e.*, "No-Further," was then the limit to which the west coast of Africa was known in Europe. But the ship sent by Prince Henry passed it, and reached Cape Bojador, so named from its great compass (it bulges out 40 leagues into the Atlantic); and here were met those strong currents running past it which had been the real barrier to the circumnavigation of Africa by the Phœnicians and Carthagenians from the West, as those which, after the voyage of Da Gama, gave their name to Cape Corrientes, north of Delagoa Bay, had prevented the Arabs from circumnavigating the vast continent from the East. Long before this, however, the Norman navigators of Dieppe are reported to have explored the west coast of Africa to the south of Cape Nam, and established factories there, from which they imported many articles of African produce, among which may be mentioned ivory, as it gave rise to the manufacture of the carved trinkets and figures for which Dieppe has been known down to the present day; and in 1402 Jean de Bethencourt, a native of Dieppe, settled a French colony in the Canary Islands (so called because they abounded with wild dogs), the discovery of which is claimed both by the French and the Spaniards. They were probably originally discovered by the Phœnicians, and have always been identified with the half mythical Insulæ Fortunatæ of classical geography. When also the island of Madeira, so called from its woods, was discovered by the expedition sent out by Prince Henry in 1418-20, it was found that it had been previously visited about the year 1344 by a young Englishman named Robert Machin, who had run away to sea with Anne Dorset, and was fortuitously cast on this island, where their romantic grave gives its name to the province of Machico. Fenchal derives its name from the quantity of fennel which grew there. An expedition of 1434-36 succeeded in doubling Cape Bojador, and, in 1444 the Portuguese obtained the Papal Bull bestowing on them the sovereignty over all the lands which had hitherto been discovered by them, and all that should be discovered as far as the Indies. The several islands of the Azores, so called from the goshawks with which they abound, were discovered at different periods between 1440 and 1450, although the Flemings claim the exclusive discovery of them in 1445. Cape de Verde (Green) was reached in 1446, and doubled in 1449; and in 1449 the Cape de Verde Islands was discovered. In 1463, three years after Prince Henry's death, the Portuguese had reached the coast of Sierra Leone, so named from the nightly roaring of the lions in the mountains which range along it; and in 1484 Diego Cam made his great discovery of the Congo River. In 1487 Bartholomew Diaz discovered the Cape of Good Hope, and called it *Cabo Tormentoso*, "Cape of Storms." "No," said the King (John II.) of Portugal, "*Cabo Buen Esperansa* rather, "Cape of Good Hope"—of finding India.

On the 12th of October, 1492, Columbus, seeking India, discovered America. He appears to have formed his theory that the East Indies could be reached by sailing to the west about 1474, after a study of the map constructed by Toscanelli on the travels of Marco Polo. After offering his services in vain, first to his native city, Genoa, and then in succession to the Kings of Portugal, Spain, and England, he still maintained his faith in the possibility of sailing to India across the Atlantic; and once, when lying sick of fever and hope deferred, he was greatly encouraged by a heavenly voice whispering to him, "God will cause thy name to be wonderfully resounded through the earth, and will give thee the keys of the gates of the ocean, which are closed with a strong chain." The first American land he sighted was an island, on which, as soon as he had gained its shore, he set up a cross, and knelt down before it and thanked the Saviour, who had enabled him, through so many perils, to accomplish the work of which he had dreamed from his boyhood; and, rising from his knees, he proclaimed with a broken voice that henceforth that island should bear the name of San Salvador. Such was his noble consecration of the quest of India. It was at daybreak of Friday, August 2, 1492, that after 18 years of weary supplication and heart-sickness, Columbus, by the aid chiefly of the old and wealthy seafaring Spanish family of the Pinzons, at last set sail from Palos, carrying with him a letter to the Great Khan of Tartary. On the 2nd of October he was still sailing due west in the parallel of 26° North. On the 7th Pinzon in the *Pinta*, having seen a flight of green parrots going to the south-west, Columbus at once steered after them, west-south-west; and at midnight, on the 11th, a sailor, Rodrigo de Triana, descried the verdant island, to which, at the break of dawn on the 12th, Columbus rowed in one of the ship's boats, and was the first European to

days, at "Ternassari" (Tenasserim), and afterwards sailed to the mouth of the Ganges, and up the river for 15 days until he came to "Cernove." He notices the charming villas on both banks of the river, and plantations and gardens, "wherein grow vast varieties of fruits, and above all those called *musa* (plantains) . . . and also the nuts which we call nuts of India" (*nuces Indicæ*, or cocoa-nuts). From "Cernove" he went on to "Maarazia" and "Buffetania," and thence returning by the Ganges, a month's voyage, he arrived at "Racha" (Aracan), whence he crossed inland to the river Dava (*i.e.*, d'Ava, the Irrawaddy), up which he sailed to the city of Ava. Here in his narrative Conti alludes to "Macinus" ("Manzi" or Southern China) and "Cathay" (Northern China), and its capital, "called Cambaleschia" (Pekin). Leaving Ava, "he arrived at the mouth of a moderately sized river, where there is a port called Xeythona (Sittoung?), and having entered the river, at the end of ten days arrived at a very populous city called Pancovia," where he remained four months. Here, he says, they have "pine apples, oranges, chesnuts, melons, . . . white sandal wood, and camphor." The "pine apples" must be a mistake, for they are a product exclusively of America, which had not yet been discovered. He now crossed to Java. He says that "in Central India are two islands towards the extreme confines of the world, both "of which are called Java. . . . distinguished from each other by the names of the Greater and Less"—the Java Major and Java Minor of other travellers, usually identified with Java and Bally, but by which Conti would seem to describe Java and Sambava. He remained in Java nine months. At fifteen days' sail beyond these islands, eastward, two others, he says, are found, "the one called Sandai (Ceram), in which nutmegs and maces grow; the other is named Bandan (Banda); this is the only island in which cloves grow, which are exported hence to the Java islands." Ceram and Bouro are the two largest of the Banda or Bandan islands. He also mentions the *lori* as a bird of Bandan, but no loris are found in the Indian Archipelago west of New Guinea. Indeed, Conti's whole account of the Indian Archipelago is vague and confused, and it is quite possible that he traversed all this part of his travels only in the delightful pages of Marco Polo. Having quitted Java, he bent his course westward for a month to "a maritime city called Ciampa (Cochin China and Cambojia), abounding in aloes, wood, camphor, and gold." In another month he came to "Coloen" (Quilon) in "Melibaria" (Malabar), where he again notices the ginger, "called by the natives *coboli*," and cinnamon "which is known there by the name of crassa," brazil wood, and pepper; and describes the jack, *amba* (mango), and a tree he names *cachi*. After a further journey of three days, he came to Coeym (Cochin), and still going northward visited in succession "Colanguria," "Paliuria," "Melianeota," and then Calicut, "a noble emporium for all India, abounding in pepper, lac, ginger, a larger kind of cinnamon, myrobolas, and zedoary." He then went on to Cambay, which he reached in 15 days, and returning to Calicut took ship to "Sechutera" (Socotra), where he spent two months. Departing thence, in five days he reached Aden, "an opulent city remarkable for its buildings;" from which he sailed "over to Æthiopia," and after seven days anchored in the port of "Barbora" (Berbera). Sailing thence after a month he arrived at "Giddah" (Jeddah), and subsequently at a port near Mount Sinai, whence he crossed the desert to "Cairos" (Cairo), where he lost his dear wife and two of his children, of the plague. From Egypt he reached Venice safely with his two surviving children.

The account of the journey into India of Athanasius Nikitin, a Russian, entitled "India in the Fifteenth Century," was first published by Mr. Major in his volume of the Hakluyt Society's Transactions, and which includes also the separate narratives of Abdul-er-Razzak, Conti, and San Stefano. Nikitin started from Twer in 1468, and descended the Volga through Kazan, and the several Tartar "*Orela*" or cantonments, and Sarai, to Astrakhan. Thence he went on to Derbend and Bakn, where he crossed the "Doria Khavalitskai" (Caspian Sea, or Sea of Khiva?) to "Chebokhara" (Bokhara.) He then re-crossed the Caspian, and lived for six months at Sareh in Mazanderan, whence he went on by successive stages to Kashan, Yezd, and Bender (Bander-Abbas as it was afterwards called), to "Hormyz" (Ormuz), where he crossed the "Doria Hondustankaia (Indian Ocean) to "Moskkat" (Muscat), and thence to "Kuzrat" (Guzerat) and "Kambat" (Cambay), where indigo grows, and "Chevil" (Chaoul). From Chaoul he proceeded inland to "Jooneer," and on to "Beurk" (Beder), where he lived for four years, visiting "Koluberg" (Kulburga), and "Pervota" (Perwoltum), which he describes as "the Jerusalem of the Hindus," during his stay. On his return home he embarked from "Dabyl" (Dabul); and after being at sea a whole month, in the following month was driven somewhere on the coast, as he says, of "Æthiopia," whence he reached Muscat in 12 days, and in nine more Ormuz. He then proceeded by land through Shiraz, Ispahan, Kashan, Sultanieh, and Tabriz, to Trebizond, where he crossed the "Doria Stembolskaia" (Black Sea) to "Caffa," or Theodosia in the Crimea, where he safely landed, after a stormy passage of a month's duration, in 1474. His description of the several ports of the Eastern Seas, which were the chief resorts of commerce in his time, are most interesting and instructive, as will be seen from the following extracts:—

"Hormuz is a vast emporium of the world. You find there people and goods of every description, and whatever thing is produced on earth you find in Hormuz. But the duties are high—one-tenth of everything."

"Cambayat is a port of the whole Indian sea, and a manufacturing place for every sort of goods, as *talach* (a sort of robe), damask, *khan*, *kiota*; and there they prepare the bluestone colour (indigo), There also grows *lek daakhyk dalon*" (*i.e.*, possibly *lac*, lac, *akeek*, agates, and *dal*, split lentals, *Ervum lens*). Elsewhere, he says also "Cambat produces the agate."

"Dabyl is also a very extensive seaport, where many horses are brought from Mysore, Rabast (Arabia), Khorassan, Turkestan, Neghostan (Abyssinia?). It takes a month to walk from this place to Beder and to Kulburgha."

"Calecot (Calicut) is a port for the whole Indian sea, which God forbid any craft to cross. . . . The country produces pepper, ginger, colour plants (dyes), muscat, cloves, cinnamon, aromatic roots, *adrach* (ginger), and every description of spices, and everything cheap."

"Ceylon is another not inconsiderable port (country) of the Indian sea. There, on a hill, is the tomb of Adam, and in the vicinity are found precious stones, *fasstises*, agate, *chinchai*, crystal *sumbada*. Elephants and ostriches live there."

The two principal inland cities of India described by him are Beder and Bijanagar. "In Beder there is trade in horses, goods, stuffs, silks, and all sorts of other merchandise, and also in black people. . . . . The rulers and nobles in the land of India are all Khorassanians." Elsewhere he describes Beder as the chief city of the whole of Mahommedan India. Of Bijanagar, he writes: "The Hindu Sultan Kadam is a very powerful prince. He possesses a numerous army, and resides in a mountain at Bicheneghe. This vast city is surrounded by three forts, intersected by a river, bordering on one side on a dreadful *jungel*, and on the other a dale. A wonderful place, and to any purpose convenient. . . . The town is impregnable."

He mentions the following countries beyond India:

"Shabait," *i.e.*, *India trans Gangem*, which produces silk, musk, sandal, gems, beads, elephants; "Pewqu" (Pegu), the products of which are *manik iakhut kyrpuk*; and Cheen and Machin (Southern China), where porcelain is made.

He mentions that diamonds are found in "Rachoor."

He gives the following distances between the different ports and countries of the eastern seas:—Ten days from Ormuz to "Golat" (Kalat); from Kalat to Degh, six days; from Degh to Muscat, six days; from Muscat to Guzerat, ten days; from Guzerat to Cambay, four days; from Cambay to Chaoul, 12 days; Chaoul to Dabul, "the last seaport in Hindostan belonging to the Mussulmans," six days; from Dabul to Calicut, 25 days; and from Calicut to Ceylon, 15 days; from Ceylon to "Shabait" (*India trans Gangem*), one month; from "Shabait" to Pegu, 12 days; and from Pegu to China, one month—"all this by sea," he adds.

Hieronimo di Santo Stefano was a Genoese, who also visited India about 1494-99, as a merchant adventurer. From Cairo, where he laid in a stock of coral beads and other wares, he passed down the Nile to "Cane" (Kaneh), from which he travelled by land through the Egyptian desert for seven days to "Cosir" (Cosseir) on the Red Sea, where he embarked on board a ship, which in 25 days carried him to "Mazua" (Massouah) "off the country of Prester John;" and in 25 days more, during which he saw plenty of boats fishing for pearls, to "Adem" (Aden); and in 35 days more to Calicut. "We found that pepper and ginger grew here . . . . . . and the nut of India" (cocoanuts). From Calicut he sailed in another ship, and in 26 days reached Ceylon, "in which grow cinnamon trees, ... many precious stones, such as garnets, jacinths, cats' eyes, and other gems . . . . . . and trees of the sort which bears the nut of India." Departing thence after 12 days he arrived at a port on the coast of Coromandel, "where the red sandalwood grows;" and, after a long stay, departing thence in another ship after 27 days, reached Pegu in "Lower India." "This country (Pegu) is distant 15 days' journey by land from another called Ava, in which grow rubies and many other precious stones." From Pegu, where he suffered many and great troubles, he set sail to go to Malacca, and, after being at sea 25 days, one morning found himself in a port of Sumatra, "where grows pepper in considerable quantities, silk, long pepper, benzoin, white sandalwood, and many other articles." After further and greater troubles suffered here, he took ship to Cambay, where, after six months' detention among the Maldives, and subsequent shipwreck, he at length arrived, but stripped of all his goods. He notices that Cambay produced lac and indigo. In his destitution, he was assisted by a Moorish merchant of Alexandria and Damascus, and after a time proceeded in the ship of a Sheriff of Damascus as super-cargo to Ormuz, in sailing to which place from Cambay he was 60 days at sea. From Ormuz, "in company with some Armenian and Azami (Irak-Ajemi) merchants," he travelled by land to Shiraz, Ispahan, Kazan, Sultaniah, and Tauris; from whence he went on with a caravan, which was plundered by the way, to Aleppo, and finally to Tripoli in Syria.

Ludovico di Varthema, a Bolognese, whose travels have been so admirably edited for the Hakluyt Society by the Rev. Dr. George Henry Badger, travelled in India and the Eastern seas from A.D. 1503 to 1508. First he sailed to Alexandria, and entering "the Nile, arrived at Cairo." Then, returning to Alexandria, he took ship to "Baruti" (Beyrut), and travelled by Tripoli to Aleppo, "which is eight days journey inland (from Tripoli), which said Aleppo is a very beautiful city, and is under the Grand Sultan of Cairo, and is the mart (scala) of Turkey and Syria, and they are all Mahommedans. It is a country of very great traffic in merchandise, and particularly with the Persians and Azamani (Adjemi), who come so far as there. This is the route which is taken to go into Turkey and Syria by those who come from Azemania "(Irak-Adjemi)." From Aleppo he went southward by "Aman" (Hamath) and Menin (near Helbon) to Damascus, "which is extremely populous and very rich. It is impossible to imagine the richness and elegance of the workmanship there. Here you have a great abundance of grain and of meat, and the most prolific country for fruits that was ever seen, and especially for grapes during all seasons . . . pomegranates and quinces . . . almonds and large olives . . . the most beautiful white and red roses that were ever seen . . . also good apples and pears and peaches. . . . A stream runs through the city, and the greater number of houses have very beautiful fountains of mosaic work. The houses are dirty externally, but within are very beautiful, adorned with many works of marble and porphyry." On the 8th of April 1503, Varthema set out from Damascus with the Haj caravan to Medina and Mecca, and he is the only European to this day who ever succeeded in reaching these holy places by this route. Speaking of the merchandise of Mecca, he says: "From India Major there comes a great many jewels and all sorts of spices, and part comes from Ethiopia; and there

set foot on the new tropical world of the west. It has been well said that never was an augury more momentous than the flight of these parrots. America was really first discovered by Leif, the son of Eric the Red, who had reached its shores somewhere between Boston and New York, A.D. 1000. But the memory of this discovery had totally passed away. Had Columbus known anything of it he would undoubtedly have steered his westward course more to the north, and not have followed the green streak of these parrots southwards, which thus determined the distribution and whole future history of the Celtic and Germanic races in the new world. By the Bull of May 4, 1493, the Pope confirmed the King of Spain in the sovereignty of America, and strictly prohibited all persons whatsoever, on pain of excommunication, to touch at any port or place within an imaginary line drawn from pole to pole, 100 leagues westward of the Azores, afterwards extended to 250 leagues beyond these islands. The Portuguese were to possess all eastward of this line. The Pope overlooked, however, that there were two sides to a globe—a fact which brought the rival sovereignties of Spain and Portugal into collision on the discovery of the Philippine Islands, in 1521, by Magellan, then in the service of the King of Spain.

It was on the 8th of July, 1497, that the expedition commanded by Vasco da Gama sailed from the Tagus for the discovery of India. Notwithstanding the full torrent of popular clamour against the undertaking, King Emmanuel, who had succeeded John II. in 1495, was determined to prosecute the project of Prince Henry; and three sloops of war, the *Angel Gabriel*, the *Saint Raphael*, and the *Pilot*, with a store ship, were fitted out, and Vasco da Gama was commissioned admiral and general, and his brother Paul and his friend Nicholas Coello were appointed to command under him. About four miles from Lisbon, on the sea shore, stands the sanctuary of Bethlehem ("Belem,") and to it, the day before his departure, Da Gama conducted the companions of his expedition to pray for its success, and the whole night was spent in the chapel in the rites of their daring devotion. On the next day, when the adventurers marched into their ships, the whole population of Lisbon were on to the beach, headed by an unending procession of priests in their robes, bearing banners, and singing anthems, in which the whole people joined; and when Da Gama gave his sails to the wind, not knowing to what fate they might bear him, the vast multitude remained immoveable by the sea till his fleet had passed away out of their sight. On the 22nd November following, at noon, he doubled the Cape of Good Hope, and, steering northward, sailed along the beautiful and richly-wooded coast described by Camoëns. On December the 8th, on leaving the bay, which Diaz had named St. Blaze, a violent storm carried the fleet into that dreadful current running between the Cape, thenceforward called Cape Corrientes, and the south-west extremity of Madagascar, which had always prevented the Arabs from extending their southward voyages along the coast of East Africa beyond the Mozambique Channel. On the 15th they sighted the island of Santa Cruz in Algoa Bay, where Diaz had left a *padrao* or cross. On the night of the 17th he passed the Rio do Iffante, the extreme point of Diaz's discovery, and on Christmas-day ("Dies Natalis") he gained sight of the land, to which he gave the name of Terra de Natal. On the 22nd of January, Da Gama reached a large river (the Quilimane), to which, from his meeting there two Arab merchants connected with the Indian trade, he gave the name of Rio dos Boos Signaes, or "River of Good Signs;" and here he dedicated a *padrao* or cross to St. Raphael. On the 10th of March he anchored off the island of Mozambique, where he was delighted to hear from the people that "Prester John" had many cities along the opposite African coast. On the 7th of April he arrived at Mombas, where a plot for his destruction was made between the Moors of the place and the pilots who had brought him from Mozambique. Sailing thence on the 13th of April, he fell in with two Arab ships, which he captured; and on Easter-day, the 15th of April, he reached Melinda, where he was informed by an Arab prisoner, would be found four ships belonging to the Christians of India. He was visited by the King of the place, and by the Indian Christians, who warned him against going on shore; and accordingly, on the 24th of April he set sail, under the guidance of a pilot named Malemo Canaca, for Calicut, before which city he anchored on the 20th of May, 1498, where he was welcomed by a Moor who spoke the Portuguese language, and where, with the permission of the Zamorin, Da Gama at once established a factory, at the head of which he placed Diego Diaz, the brother of the first discoverer of the Cape of Good Hope. He also dedicated a cross on the seashore before Calicut to St. Gabriel. Visiting Aujediva and another island near it, on which he raised a cross to St. Mary, Da Gama, after having suffered much from the enmity of the Moors towards the Portuguese, set sail westward from Aujediva on the 5th of October, carrying a letter with him from the Zamorin to the King of Portugal, to the following effect:—"Vasco da Gama, a nobleman of your household, has visited my kingdom, and has given me great pleasure. In my kingdom there is abundance of cinnamon, cloves, ginger, pepper, and precious stones in great quantities. What I seek from thy country is gold, silver, coral, and scarlet." On the 2nd January 1495, Da Gama found himself off Magadoxo, and on the 7th again anchored before Melinda, where he on this occasion set up a cross to St. Stephen. On the 1st of Februrary he reached the island in Mozambique on which he had landed on his outward voyage, and where Da Gama now erected a cross to St. George. On the 3rd of March he reached the Bay of St. Blaze, and on the 20th doubled the Cape of Good Hope, reaching Lisbon, where he was received with great pomp by the King, and great popular rejoicings, at the end of August or beginning of September, 1499.

But already the Portuguese had reached India overland before the arrival of Da Gama at Calicut. King John II., as soon as he found that the difficulties of the passage to India round the Cape of Good Hope were likely to be surmounted, ordered Pedro de Covilham and Affonso de Payva to travel to India overland, in order to obtain information respecting the trade and navigation of the Eastern seas. They set out from Portugal in 1487, and proceeded by

Naples, Rhodes, Alexandria, and Cairo, to Tor on the Red Sea. There they heard of the great trade with Aden and Calicut. From Aden, Payva went into Abyssinia, and Covilham sailed in an Arab vessel to Cannanore, and thence to Calicut and Goa, and was the first Portuguese who was ever in India. He returned by Sofala, and examined the gold mines there, where he received some information of the island of Madagascar, or "Island of the Moon" as it was called by the Moors, and Aden to Egypt, where he met with the Rabbi Abraham of Beja, and Joseph of Lemago, two messengers who had been sent by King John II. to inquire after his progress, and from whom he heard of the death of Payva. These messengers he immediately sent back to King John with the following report:—"That the ships which sailed down the coast of Guinea might be sure of reaching the termination of the continent by persisting in a course to the south, and that when they should arrive in the eastern ocean their best direction must be to inquire for Sofala and the Island of the Moon." Then Covilham, again taking ship to Aden, sailed to Ormuz, and thence he visited Abyssinia, where he was kept a prisoner until 1526, when he returned to Europe.

When the Portuguese, at last rounding the Cape of Good Hope, burst into the Indian Ocean like a pack of hungry wolves on a sheep walk, they found a peaceful and prosperous commerce being carried on along all its shores, which had been elaborated during 5,000 years by the Phœnicians and Arabs. The great store cities of this trade were then at Calicut, Ormuz, Aden, and Malacca. Here were collected the cloves, nutmegs, and mace, and ebony of the Moluccas, the sandal wood of Timor, the costly camphor of Borneo, the benzoin of Sumatra and Java, the aloes wood of Cochin China, the perfumes, gums, spices, silks, and innumerable curiosities of China, Japan, and Siam, the rubies of Pegu, the fine fabrics of Coromandel, the richer stuffs of Bengal, the spikenard of Nepaul and Bhatan, the diamonds of Golconda, the pearls, sapphires, and cinnamon of Ceylon, the pepper, ginger, and satin wood of Malabar, the lac, agates, and sumptuous brocades and jewellery of Cambay, the costus and graven vessels, wrought arms, and broidered shawls of Cashmere, the bdellium, civit, and musk of upper India, the galbanum of Khorassan, the assafœtida of Afghanistan, the sagapenum of Persia, the ambergris and ivory of Zanzibar, and the myrrh, balsam, and frankincense of Arabia and Berbera. From Ormuz they were forwarded to Europe by the Persian Gulf and river Euphrates, whence they were carried by the caravans to Aleppo, and Damascus, and to Trebizond, or were distributed, by way of Armenia and Persia, throughout Tartary and Muscovy. The merchandise collected at Aden was sent on to Tor or to Suez, and thence by caravan to Grand Cairo, and down the Nile to Alexandria, from which city it was shipped to Venice and Genoa, and other ports on the Mediterranean. It was the great object of the Portuguese, on entering the Indian Ocean, to become possessed of the great Arab emporia of Calicut, Ormuz, Aden, and Malacca.

The difficulties which the Portuguese had experienced in their first voyage, at Calicut, led them, in their second voyage to India, to send out a fleet of thirteen ships with 1,500 soldiers, which sailed from the Tagus under the command of Cabral, in March 1500. On his way out, Cabral was driven by a storm on the coast of Brazil, of which country he must, notwithstanding the claims of Pinzon, one of the companions of Columbus, and of Martin of Nuremberg, be regarded as the first discoverer. Its name is derived from the well-known brazil or "sappan" wood of the East Indies, from a similar fiery coloured dye-wood being found there also. Cabral then proceeded on his voyage, and, after visiting Mozambique, Quiloa, and Melinda, arrived at Calicut in September. Having quarrelled with the Zamorin, the latter instigated an attack on the Portuguese factory, which was pillaged and burnt, and 50 people that were in it massacred. Cabral took ample revenge, and then proceeded to Cochin, where he settled a factory, and concluded an advantageous treaty with the Prince. He also visited Quiloa and Cannanore. On his homeward voyage he settled factories at Melinda, Mombas, and Querimba, and compelled several of the chiefs on the east coast of Africa to become tributary to Portugal; and after rounding the Cape discovered the island of St. Helena, on St. Helena's day, 1502. The Portuguese (De Nova) first discovered Ascension Island on Lady-day, and so first called it Conception Island, and again on Ascension-day, 1501. In 1500, also, Corte Real, who was sent out by the King of Portugal to prosecute a westward route to India, discovered the Gulf of St. Lawrence, and the coast of Labrador as far as Hudson's Bay. Before Cabral arrived in Portugal, King Emmanuel in 1502, sent out a fleet of 20 ships to India, under the command of the great Vasco de Gama, and obtained from Pope Alexander VI. the Bull, which conferred on him the title of "Lord of the Navigation, Conquests, and Trade of Ethiopia, Arabia, Persia, and India." Da Gama, on his outward voyage, visited Sofala, and settled a factory there and at Mozambique, and obtained the submission of the Prince of Quiloa to Portugal. Then, proceeding to India he formed an alliance with the Kings of Cannanore and Cochin against the Zamorin of Calicut, and having severely cannonaded the latter town and the Zamorin's palace, and plundered a number of Arab ships in the harbour, sailed back to Europe in December, 1503. In that year nine ships were sent out from Lisbon—three under the Great Alfonso de Albuquerque, three under Francis de Albuquerque, and three under Antony de Saldanha. Saldanha, who was the first Portuguese to visit Saldanha Bay, was especially commissioned to blockade the Red Sea against the overland Indian trade through Egypt. One of his lieutenants, Ruy Lorenzo, discovered the island of Zanzibar, which, with Mombas and Brava, became tributary to Portugal in this year. Francisco Albuquerque, on reaching Cochin, found the King closely besieged by the Zamorin of Calicut, who had made war on him for entering into an alliance with the Portuguese. The Zamorin was soon compelled to sue for terms to Francisco Albuquerque, who, having obtained permission to build a fort at Calicut, and after settling a factory at St. Thome, left a detachment of his force for the protection of the allies of Portugal in India, and set sail for Europe. But neither he nor his ships were ever heard of again.

One of the ships commanded by Alfonso de Albuquerque, on the outward voyage, discovered the island of Socotra, which was re-discovered in 1504-5 by Diego Fernandez Pereyra, who commanded one of the ships in the small fleet sent out under Lopez Soarez in 1504. The Portuguese discovered the island afterwards known by the name of Mauritius, in 1505, in which year the King of Portugal sent out another large fleet of 20 sail under Francisco de Almeyda, the first Portuguese viceroy of India. His son, who in 1506 discovered the island of Madagascar, or St. Lawrence, in 1507, accidentally discovered the island of Ceylon. In 1507 the King of Portugal sent out a fleet of 16 ships under Tristan da Cunha, who discovered the islands of that name, and also Madagascar, thus sharing with Lorenzo Almeyda the honour of being the first discoverer of the latter island. In the same year King Emmanuel also sent out six ships under Alfonso de Albuquerque, who rapidly extended the power and dominion of the Portuguese in the East. His instructions were to exclude the Indian trades from the Red Sea and Persian Gulf. In 1507 a strong fort was built at Sofala, Malacca was visited for the first time, Muscat rendered tributary, and possession taken of by Ormuz; the Zamorin also was reduced to complete submission, and the Maldive Islands were surveyed. In 1508, the island of Socotra was taken, and the island of Sumatra first visited. It was in this year that the pseudo-Caliph of Egypt, secretly abetted both by the Zamorin of Calicut and the Venetians, appeared in the Indian seas to dispute the sovereignity of the Portuguese in the East. The Venetians supplied the timber, which with great difficulty was carried from Alexandria to Suez, for building the Sultan's ships, and when the fleet was ready it sailed for India, and, falling in with a Portuguese squadron at Chaoul (some say Diu), defeated it, Lorenzo de Almeyda, the Viceroy's son, being slain in the action. This victory raised a spirit of opposition to the Portuguese throughout Western India, but the Viceroy, collecting another fleet, took Dabul, and totally dispersed the Egyptian fleet off Diu in February, 1509. Later in this year Albuquerque succeeded as viceroy to Almeyda, who died on his homeward voyage. In the meanwhile the island of Ormuz had revolted and forced the Portuguese garrison to retire to Socotra, a disaster which so alarmed King Emmanuel that he at once ordered out a fleet of 17 ships, with 3,000 troops, under the command of Don Fernando Continho, with orders to co-operate with the Viceroy. This was in addition to the fleet of 13 ships under De Aguiar, which had sailed a little earlier in the same year, 1509. The first great operation was against Calicut; from the assault of which place, however, the Portuguese fleet had to retire with so great loss, that Albuquerque, in order to recover their prestige, at once attacked Goa, which surrendered to him, February 17th, 1510. It was soon after retaken by the natives; but on November 22nd it was again taken possession of by the Portuguese, and made the capital of all their possessions in the east. Albuquerque next set sail for Sumatra, and on 24th July, captured Malacca, the key of the navigation and the emporium of the whole trade of the China Seas and Indian Archipelago. Three of his ships were sent on, in 1512, to the Spice Islands, and visited Ternate, Bouro, Amboyna, and Banda. They visited also Polembang in Sumatra, and others of the fleet visited Siam. The Portuguese also in this year plundered and destroyed Surat. In 1513, Albuquerque made an unsuccessful attempt upon Aden, from which place he then proceeded up the Red Sea, which was then for the first time entered by a Portuguese fleet. He wintered at the island of Camaran. Early in 1514, he recovered possession of Ormuz, and, returning to India, died on the bar of Goa, December 16th, 1515, leaving the Portuguese power in the East at its height. In 1516 the successor of Albuquerque, Soarez, reduced Aden to temporary submission, took and burned Zeyla, and unsuccessfully attacked Jeddah. In 1517 he personally led an expedition against Colombo, where the King agreed to pay 1,200 quintals of cinnamon annually, as tribute to the Portuguese, who also obtained possession of Point de Galle. In this year they also settled a valuable trade at Canton, and took and burned the town of Berbera on the Sumali coast of Africa, opposite Aden. In 1518, Sequeyra succeeded Soarez as Viceroy, and the Portuguese trade was first opened with Bengal.

In 1519, the Spaniards laid claim to the Banda, or five (really ten) Nutmeg Islands, and the Moluccas, or five Clove Islands, as falling within the line of their sovereignty as laid down by the Papal Bull of 1493. From 1505 the Court of Spain had earnestly engaged in the project of finding a way to the "Spice Islands" from the west, and in 1508, Pinzon and de Solis sailed in search of them, and explored the coasts of South America to the 40th degree of south latitude. It was not, however, until 1515 that the Pacific was discovered, when Nunez de Balboa, who had been placed in 1510 in command of the Spanish colony of Santa Maria on the Gulf of Darien, having gone on an expedition into Sierra de Quarequa, suddenly from one of its peaks stared down on the boundless sea which lay out stretched below him—from the narrow isthmus on which he stood, to where, to north, and west, and south, it was lost in space. This was the true discovery of America—that it was not, as Columbus believed to his dying day, the eastern coast of Asia, or westernmost Indies, but a separate continent; and as this new world, with the vast waste of ocean beyond it swam into his eyes, and all its moral significance flashed upon his mind, kneeling down upon the scarped summit from which he gazed, Balboa raised his hands to heaven in silent wonder and gratitude at the immensity of the revelation which had been made to him. Then, descending with all his men to the shore of this great sea, and wading up to his waist in its waters, with his drawn sword, he claimed possession of the infinite expanse in the proud names of Aragon and Castile. In October, 1515, De Solis was again sent out to discover the "Spice Islands" from the west, and in January, 1516, entered the Rio de la Plata, originally named Rio de Solis; its present name not having been given to the river until 1525, when Diego Garcia found some plates of silver, probably from the mines of Potosi, in the hands of the wild Indians on its banks. De Solis, having anchored in the mouth of the river, attempted to explore the country inland, when he and eight of his men were set upon, massacred by the natives, and roasted,

and devoured in sight of his ships: on which the disheartened expedition returned to Spain. In 1517, Ferdinand Magellan, a Portuguese malcontent, who had been present at the capture of Malacca, proceeded to Valladolid, and gave it as his opinion that the "Spice Islands" fell within the Spanish boundary, and undertook to take a fleet thither by the south of the American continent. Accordingly, in 1519, Charles V. gave him five ships for the purpose. Every one of them was accompanied by a Portuguese pilot, and the *Santiago* was commanded by Joano Serrano, an old Portuguese, on whose knowledge of the East, and especially of the Moluccas, of which they were in search, Magellan placed great reliance. On the 21st of October, 1520, St. Ursula's Day, he reached the Cape, which he called "Cabo de las Virgines" (Cape Virgin) at the entrance of the Strait which we call after Magellan, but which he named San Vittoria, in affectionate honour of his own flagship. From many bonfires being seen on the land south of the Strait, he named it Tierra del Fuego. On the 27th of November he emerged from the Straits into the open Pacific Ocean, and the Cape which terminated the Strait on his left (on Tierra del Fuego) he named "Cabo Deseado" (the "Desired"), now called Cape Pilares. On the 6th of March, 1521, he discovered the beautiful islands, to which, from the thievish propensity of their inhabitants, he gave the name of the Ladrones ("thieves"); and on the 16th, the islands he called the Archipelago de San Lazaro, a name afterwards changed by Villalobos to that of the Philippines, in honour of Philip II. of Spain. On one of these islands Magellan was slain in a skirmish with the natives, brought on by his proselytising zeal, when Jaono Serrano and Duarte (Odoardo) Barbosa were elected joint commanders of the expediton. On Serrano's death, Caraballo was elected commander-in-chief. On the 8th July, 1521, they anchored before the city of Borneo; and on Wednesday, November 6th, 1521, they at last descried the long sought-for Molucca Islands, the object for the discovery of which, by a western route, their daring adventure had been undertaken, On the 8th they anchored at Tidor. In the December following, of the two remaining ships of the expedition, it was resolved to send the *Trinidad* back to Spain by Panama and the Strait of Magellan, and that the *Vittoria*, under Del Cano, should sail forthwith to Europe by the Cape of Good Hope. In order to escape the observation of the Portuguese, her course was steered so far south as the 42nd parallel of latitude; but, with all their caution, they approached within five leagues of the Cape on the 6th of May, 1522. On the 9th of July, when they reached the Cape de Verd Islands, they were obliged to put in at Santiago for provisions; but to prevent the suspicions of the Portuguese being aroused, said they had come across from America. It was here that they discovered that in sailing round the world they had lost a day, for while by the *Vittoria's* log it was Wednesday, the 9th of July, at Santiago it was Thursday, the 10th. On the 6th of September the *Vittoria* arrived at San Lucar, the only survivor of the noble fleet which had sailed from the same port on the 20th of September, 1519. The circumnavigation of the world, which had originated in the dispute between Spain and Portugal about the possession of the Moluccas, was completed, and the sphericity of the earth demonstrated against the authority of Cosmas Indicopleustes, which had ruled geographers for nearly a thousand years. Charles V. received Del Cano with the highest distinction, and conferred on him a life pension and a coat of arms, which bore branches of clove, cinnamon, and nutmeg, with a globe for the crest, and the motto "*Primus circumdedisti me.*" In regard to the dispute as to the respective rights of Portugal and Spain to the "Spice Islands," the King of Spain was confirmed in the possession of the Philippine Islands, but the Moluccas were finally surrendered to the King of Portugal, under the agreement that the King of Portugal lent the King of Spain 350,000 ducats in respect of any claims which the latter might have on the Moluccas, in the possession of which the King of Portugal was not to be disturbed until the money was repaid, which was never done.

In 1520, the Bahrein Islands in the Persian Gulf were subjected to the Portuguese; and in 1521 Diu and Acheen were unsuccessfully attacked, and Ternate occupied. In this year the Venetians, alarmed by the decrease of their overland trade, made a proposal to the King of Portugal to take all the spice annually imported into Lisbon by the Cape of Good Hope, at a certain fixed price, but the offer was rejected. In 1524, Vasco de Gama came out to India for the third time as Viceroy. In 1525, the Portuguese were besieged by the Zamorin in their citadel at Calicut, and must have surrendered had not Da Gama (who died in 1527) arrived to their relief. In 1525-26 they discovered New Guinea and Celebes, and plundered and destroyed Dofar on the coast of Arabia, and Massouah on the coast of Abyssinia. In 1527, Mangalore, Perca, and Chetwa were burnt by them; and Tidore was taken from the Spaniards, and Borneo discovered in 1529 the towns of Bassein and Tannah were subjected. In 1570 Damaum was taken, and permission obtained to build a fort at Diu, but the Portuguese were expelled by the natives from the island of Ternate. During 1530, 1531, and 1532, Surat and Gogo, Pate, Mangarole, and most of the other towns on the coast of Guzerat, were destroyed by the Portuguese; and in 1532 Aden became tributary to them; and in 1534 Bassein was ceded to them in perpetuity. In 1537 they discovered the island of Magindanao. In 1538 St. Francis Xavier was sent out to Goa with Don Garcia de Naronha, the 11th viceroy, with the object of the conversion of the natives to Christianity, in the hope that it would better reconcile them to the Portuguese rule. In this year also the Turks fitted out a strong fleet at Suez, and made an attempt upon Diu, in which they failed; but on their return to the Red Sea, they succeeded in expelling the Portuguese from Aden. About the year 1540, the Portuguese established their trade with Patania, Cambajia, and Cochin China; and in 1542 the coast of Japan was discovered by three Portuguese, who were driven thereon in a junk bound for Siam and China. In 1545, the King of Cambay having attempted to drive the Portuguese from Diu, they took and destroyed Gogo. Delagoa Bay was visited by them for the first time this year. In 1547 the King of Acheen

made an unsuccessful attack on Malacca. In 1555 the Portuguese took and plundered Tatta on the Indus, and put 8,000 of the inhabitants to death.

At this period the dominion and renown of the Portuguese in the Indian Seas were at their highest, although, after the death of Albuquerque, they appear, notwithstanding the large reinforcements sent to them from Europe, to have been rather employed in defending the possessions they had acquired, than extending or even consolidating their power. From Japan and the Indian Archipelago, to the Red Sea and Cape of Good Hope, they were the sole masters and dispensers of the treasures and riches of the East, and their possessions along the Atlantic Coast and Brazil completed their ultramarine empire. But from this very period its decay began. It was essentially a commercial empire, which had been rapidly raised on an insufficient basis of territorial sovereignty, and the Portuguese never commanded the necessary military and political resources for its maintenance and defence. The Portuguese also were, in another way, unprepared for the commerce of which, through their great maritime discovery, they obtained the control. The national character had been formed in their secular contest with the Moors, and above all things they were knights-errant and crusaders, who looked on every Pagan ("blackamoor") as an enemy at once of Portugal and of Christ. It is impossible for any one who has not read the contemporary narratives of their discoveries and conquests to conceive of the grossness of the superstition and the cruelty with which the whole history of their exploration and subjugation of the Indies is stained. Albuquerque alone endeavoured to conciliate the good-will of the natives, and to live in friendship with all the Hindu Princes, who were naturally better pleased to have the Portuguese, as governed by him, for their neighbours and allies, than the Mahommedans whom he had expelled or subdued, It was the justice and magnanimity of his rule which did more to extend and confirm the power of the Portuguese in the East, than even the courage and success of his military achievements; and in such veneration was he held by the Hindus, and even by the Mahommedans, in Goa, that they were accustomed to repair to his tomb, and utter their complaints, as if in the presence of his shade, and call upon God to deliver them from the tyranny of his successors. The cruelties of Soarez, Sequeyra, Menezes, Da Gama, and succeeding viceroys drove the natives to desperation, and encouraged the Princes of Western India, in 1567, to form a league against the Portuguese, in which they were at once joined by the King of Acheen. Their undisciplined armies were not able to stand against the veteran soldiers of Portugal, 200 of whom at Malacca utterly routed and put to flight a force of 15,000 of the enemy and 200 guns. When, in 1578, they were again besieged in Malacca by the King of Acheen, the small garrison of the Portuguese there succeeded in inflicting a loss on him of 10,000 men, and all his cannon and junks. But these incessant attacks on the Portuguese settlements evinced the decline of their power, and the increased military forces sent out to India proved an insupportable drain on the revenues and population of Portugal. In 1558, John III., King of Portugal, died, and was succeeded by Sebastian. The power of Portugal in Asia having greatly declined during the preceding reign, Sebastian, on his succession, in the hope of re-establishing it, appointed Don Constantine Braganza, one of the royal family, to be the 20th viceroy, with the fullest powers. But he was able to effect little more than building a fortress at Damaum, and another at Manaar, and reducing the King of Jafnapatam to become tributary. The quick succession of viceroys after him destroyed all possibility of a revival of the Portuguese power, as it exposed the vigorous effects of one to the errors of his successors. Thus Don Luis D'Ataide's able rule as 24th viceroy from 1567 and 1571—during which Onore and Barcelore were reduced, and friendly relations were resumed with the native princes of India and the Indian Archipelago—was followed within the next five years by the weak and disastrous administrations of no less than four different viceroys, Don Anthony de Noronha, Antony Monez Barreto, Don Laurence de Tavora, and Don James de Menezes. At this last juncture, when the Portuguese power had almost been dissolved, Don Luis D'Ataide was sent out a second time in 1579, as 29th viceroy. Though he lived only one year, by his exertions he restored vigour to the Government in India, but in vain. It was in 1580, the same year in which Don Luis D'Ataide died, that King Sebastian was killed at the battle of Larache in Africa, when the Crown of Portugal became united with that of Spain, under Philip II.—an event which proved the last blow to the maritime and commercial empire of Portugal. It proved fatal in many ways, but chiefly because the interests of Portugal in Asia, were now subordinated to the European interests of Spain.

In 1640, Portugal again became a separate kingdom, but in the meanwhile the Dutch and English had appeared in the Eastern Seas, and before their indomitable competition the Portuguese commerce and dominion of the Indies withered away as rapidly as it had sprung up. They obtained possession of Macao, as a station for their China trade, in 1586; but from this date the only notable events in their Asiatic history are the succession of their losses to the Dutch and English.

At the period of the acquisition of Macao they possessed the following places in the East:—

On the East Coast of Africa: Melinda, Quiloa, Querimba, Sofala, Mozambique, and Mombas.

In Arabia: Aden and Muscat.

In Persia: Bussorah and Ormuz.

In India: Diul and Tatta on the Indus, Bandel, Diu, Damaum, Assarim, Danu, St. Genes, Agaciam, Chaoul, Dabul, Basseim, Salsette, Mahim, Bombay, Tannah, Caranja, Goa, Onore, Barcelore, Mangalore, Cananore, Calicut, Cranganore, Cochin, Quilon, Angamate, Negapatam, Meliapur, St. Thome, Masulipatam, and several other places on the Coromandel coast, and in Bengal.

In Ceylon: Manaar, Point de Galle, Colombo, Jafnapatam, and other places.

In further India: Malacca, and factories at Pegu, Martaban, Junkecylon, and other places.

In the Indian Archipelago: The Moluccas, and Banda Islands, and other places.

In China: Macao, and the Island of Formosa.

All these possessions were subordinate to the supreme Government at Goa, where the Viceroy

presided over the civil and military, and an archbishop over the ecclesiastical affairs of the whole of Portuguese Asia.

They had, strange to say, no possessions in Java or Sumatra.

The period of the highest development of their commerce was probably from 1590 to 1610, when their political administration in India was at its greatest degradation, on the eve of the subversion of their power by the Dutch. At this period a single fleet of Portuguese merchantmen, sailing to Cambay or Surat, would number so much as 150 carracks. Now only one Portuguese ship sails from Lisbon for Goa in the year, and their only remaining possessions in India are Goa, Damaum, and Diu; so low have a people fallen who once commanded all the coasts of Africa and Asia, from the Cape of Good Hope to Japan, and the whole commerce of the Eastern Seas. Of a truth is God "a consuming fire."

Contemporary Writers on the early Portuguese Period.

The narratives and other writings of contemporary travellers throw great light on the early operations of the Portuguese in India; and the most interesting of all is the description left us of "The Coasts of East Africa and Malabar" by Duarte Barbosa, a Portuguese, which has been translated and edited for the Hakluyt Society, by the Hon. Henry G. T. Stanley, 1866. Barbosa was a cousin of Magellan, and was with him at the capture of Malacca, and accompanied him in his circumnavigation of the globe. He fully describes the East African and Malabar Coast, Bijanagar, Bengal, Orissa, further India, the Indian Archipelago, and China, and the trade of the Eastern Seas, as it was found by the Portuguese on their first entering into them. He gives a detailed account of the trade in rubies, diamonds, emeralds, and other precious stones, and a special account of cloves, ginger, and cinnamon, and a most interesting price list of the drugs and spices then sold at Calicut, namely, "lacca" of Martaban, "lacca" of the country, "tincal" (borax), "canfora grossa," "canfora" for anointing the idols, "Aquila" (eagle-wood), genuine "aloes" (*i.e.*, aloes-wood or eagle-wood), "almiscar" (musk), "beijoim" (benjamin), "tamarindos," "calamo aromatico" (sweet flag), indigo, "mirrha," "encenso," "ambar," "mirabulanos, emblicos, bellericos, e chebulos," cassia, "sandalho vermelho" (red-saunders wood), "especinardo" (spikenard), sandallo blanco" (sandalwood), "noz moscada" (nutmegs), "macis," "turbit," "anil" (indigo, *i.e.*, *nil*), "erva de vermes" (wild silk?), "zerumba," "zedoaria," "sagapeno," "aloes cacotorino," "cardamomo," "ruibarbo," "tutia," "cubebas" or "china cubelo," "opio," and "opio" "prepared in Cambay."

Camoens travelled in India and the East, and wrote the greater part of the "Lusiad" there, between A.D. 1553 and 1569. On his return from Macao he was wrecked on the coast of Cambogia, and of all his property succeeded only in saving the MS. of the "Lusiad," deluged with the waves, through which he forced his way, clinging to a plank, to the shore. It is not simply the national epic of the Portuguese, but the epic of the universal system of modern commerce, which was founded on the discovery of India, as it exists to the present day. There can be no doubt of the historical truth which underlies the supernatural machinery and elevated imagery and fervour of Camoens' great poem; and indeed his geographical descriptions, more particularly of the new-found coasts of Southern Africa, often fail, through their very accuracy, to rightly affect the imagination, as Milton does so powerfully by his vague enumeration of

> "the less maritime kings
> Mombaza, and Quiloa, and Melind,
> And Sofala, thought Ophir, to the realm
> Of Congo, and Angola farthest south."

The real value of the "Lusiad," however, is not as a record of authentic discovery, but as evidence of the higher moral and spiritual aims of the Portuguese in the conquest of the East; the history of which, but for the light thrown on it by Camoens, would only preserve the memory, better lost, of deeds of indescribable tyranny, senselessness, and shame. Ferdinand Mendez Pinto has incurred immortal infamy as a liar, simply on account of the sickening atrocities which he describes, without any reticence, or apparent consciousness of their fearful guilt. He it is who is referred to by Congreve:—"Ferdinand Mendez Perite was but a type of the thorough liar of the first magnitude." But Faria y Sousa, the author of "The Portuguese Asia," regards him as a true historian. He was a promiscuous vagabond, pirate, and cut-throat, in India and the Eastern Seas, from 1537 to 1558; and his "Perigrinations," published in 1614, afford the most frightful and harrowing picture on record of the moral depravity and inhuman bloodthirstiness of the Portuguese adventurers of his period, and of the confusion and misery brought by them on the people of the shores of southern Asia, whose peaceful overland commerce, of 5,000 years' growth, with Europe, they overthrew within a generation of Da Gama's rounding the Cape of Good Hope.

In 1520, the Portuguese Viceroy in India sent an embassy, by way of Ormuz, to the Persian Court, the narrative of which, by Antonio Tenreiro (Lisbon, 1763), is one of the earliest accounts we possess of the trade through Persia, at the time when it first began to be affected by the competition of the Cape route. Nearly a century later, in 1611, Fray Gaspar de San Bernardino, of the order of St. Francis, undertook the journey by land from India, by way of Mombasa and Socotra, and the Persian Gulf to Portugal; and his narrative bears witness to the complete revolution which had now taken place in the course of the trade between India and Europe, through the Euphrates Valley and Syria.

To Englishmen, one of the most interesting Portuguese travellers in the East was Francis Pyrard de Laval. He went out to India in 1601, and stayed many years in Goa, where, he tells us, he met Italians, Germans, Flemings, and Frenchmen, the adventurous spirits, in short, of every country of Europe as well as of Asia. There, too, he met three Englishmen, among the first ever seen in India, prisoners of the Portuguese, who probably belonged to Hawkins' expedition; and Laval observes with a sort of prophetic apprehension that, even fast bound in irons as they were, they were a proud-looking set, who took every opportunity of showing their contempt for the

Frenchmen, Portuguese, and other foreigners around them.

In 1663, Father Manuel Godinho, of the Society of Jesus, returned from Goa to Lisbon overland by Gombroon. He begins by deploring the almost total downfall of the Portuguese Indian empire, and describes the rising trade of Surat, which, under the English, had gradually supplanted Goa as the emporium of Southern Asia. He describes it as then, perhaps, the richest city of the world.

About the same time Pedro Cubero travelled in India. He set out from Moscow with the Russian Ambassadors to the Persian Court, and from Ormuz sailed by Damaum to Surat, Goa, St. Thome, and Malacca. He, too, notices the complete decay of the power of the Portuguese, and how the Dutch and English had now carried off all their commerce.

The Dutch in the East.

The Dutch were later than the English in trying to get to India, but, owing to their early established indirect trade with India through Lisbon, they succeeded in getting there before us, and they altogether outstripped us in the great geographical discoveries made in the "South Sea" during the 17th century. Before Lisbon rose to notice, and while Venice and Genoa were still at the height of their prosperity, the carrying trade of the Netherlands, for its own fisheries and manufactures, rendered its cities the natural entrepôts for the commerce between Northern and Southern Europe. It was by the merchants of Bruges that the imports of Genoa and Venice from the East were originally distributed over Northern Europe, and by those of Nurenberg and Augsburg, through Central Europe. But, when the trade was diverted to Lisbon and Venice, Genoa, Nurenberg and Augsburg became in consequence deserted, and Bruges also, owing to the interruptions to which, as has already been stated, the port of Sluys was about this time subjected, the treasures of the Indies were in turn distributed to Northern Europe through Antwerp, and after its destruction by the Spaniards (1576-1585) through Amsterdam. On the seven northern provinces ("United Provinces") of the Netherlands declaring their independence in 1580, Philip II., under whom the Crown of Portugal was in the same year (1580-81) united to that of Spain, forbade the merchants of Amsterdam to trade with Lisbon. This interdict, however, served only the more to quicken the native spirit and enterprise of the Dutch, and the period from the sack of Antwerp, in 1576, to the treaty of Munster, in 1648, was that of the rise of their Eastern commerce and dominion. By that treaty this energetic and indomitable people actually compelled the Spaniards to trade with the East only by Cape Horn (discovered and named by Schouten, 1616); and thus, by a stroke of the pen as it were, deprived Spain and Portugal of all the advantages of the discoveries of Columbus and Da Gama. Between 1602 and 1620 they seized the principal settlements of the Portuguese in the East, and by 1661 had expelled them from all but the remnants of their once world-wide empire they hold to this day. At this time the English were still scarcely tolerated by them in the Indian Seas, and the 80 years from 1661 to 1741 was the period of the greatest success and power of the Dutch in the East.

When the supremacy of Spain at sea was shattered at a blow, in 1588, by the destruction of the "Invincible Armada," the merchants at Antwerp, who had emigrated to Amsterdam, at once saw their opportunity for establishing a direct trade with India. At first, to avoid interference with the Portuguese rights under the Papal Bull of 1492-93, they, following the example of the English, attempted to open communications with the East, by sailing round the north coasts of Europe and Asia. William Barentz made his first abortive attempt in 1594, and the second with Hemskirk in 1595, and the third, in which he perished, in 1596. Then the Dutch resolved to take the direct passage round the Cape of Good Hope, and Cornelius Houtmann's fleet was despatched to India. He left the Texel on the 2nd February, 1595, "crossed the Line" the 14th of June, "doubled the Cape" the 2nd August, and landed at Sumatra the 11th July, 1596, and entered the harbour of Bantam the 22nd July following. He returned to the Texel in 1597. Before his return, another set of merchants had sent out James Van Neck; and Houlman's second expedition, in which he was slain, went out in 1598, and returned in 1600-1601. Companies were now formed all over the United Provinces, which were, in 1602, amalgamated by the States-General in one Joint Stock Corporation, entitled "The Dutch East India Company." They had, in their first voyage to Bantam, experienced much opposition from the Portuguese, in consequence of which a war commenced, by which the Portuguese interests in India suffered very considerably. In 1603, the Dutch, with a large force from Europe, made attempts to dislodge the Portuguese from Mozambique and Goa, in both of which they failed, but they succeeded in expelling them from Amboyna and Tidore, and also in settling factories on the coasts of Malabar and Coromandel, in Ceylon, and at Jacatia and Bantam. In 1604 the Spaniards at Manilla, being aware of the defencelessness of the islands in the Indian Archipelago under the Dutch, proceeded with an expedition, and captured them all. But the Dutch, on their return from Malacca, the siege of which they were compelled to raise, succeeded in wresting from the Spaniards the whole of their conquests. At this period they are stated to have had factories at Mocha, in Persia, at Cambay, in Malabar, Ceylon, Coromandel, Bengal, Aracan, Pegu, at Acheen, Jambee, Palembang, Bantam, in Cambojia, Siam, Cochin China, Tonquin, China, and Japan, exclusive of the entire possession of the Moluccas and the factories taken from the Portuguese in the Banda Islands. The Mauritius, first discovered by the Portuguese in 1505, had been occupied by the Dutch in 1598, and named after their renowned General and Stadtholder, Prince Maurice of Nassau (Orange).

In 1611, they were driven out of Tidore and Banda by the Spaniards. In 1612, the King of Candy called in the Dutch to assist him against the Portuguese, and in return gave them the monopoly of the cinnamon trade of the island. In this year also they took Timor from the Portuguese. In 1614, they established a factory at Masulipatam, and in 1619 acquired the sovereignty

of Java, where, on the 12th of August in that year, they laid the foundation of the city of Batavia as the seat of the Supreme Government of the Dutch possessions in India, which had previously been at Amboyna. It was about the same time, namely, in 1622, that they founded the city of Manhattan, now New York, in America. In 1622, they massacred the English in Amboyna; and although the British Government, which at that time was entering on the troubles of the Stuart dynasty, was forced to tamely submit to the outrage, the lasting animosity of the English people was all the more, thereby, roused against the Dutch rivals of the English Company, which thenceforth was always sure of the national sympathy in its contest for predominence in the East. But from the date of the massacre of Amboyna to 1661, and even later, was a period of great humiliation for England in the East. We fell into disrepute in almost every Asiatic country with which we had dealings, for beheading King Charles I., and everywhere we were vilified and oppressed by the Dutch. Perhaps our greatest abasement was reached when Van Tromp sailed down the Channel with a broom at his masthead, after his great victory over Blake off Dover, of the 19th May, 1652.

In 1627, De Nuytz discovered the south coast of Australia; and in 1628 De Witt discovered West Australia, and Carpenter the north coast of Australia. (Torres Strait was discovered in 1606 by Louis Vaez de Torres.) In 1635 the Dutch expelled the Portuguese from Formosa, in 1638 from Batecalo, Trincomalee, Negombo, and Point de Galle, and in 1640, when Portugal again became a separate sovereignty, from Malacca. In the same year the Portuguese were expelled from Japan at the instigation of the Dutch. In 1642 Tasman discovered Van Diemen's Land and New Guinea. In 1651 the Dutch settled a colony at the Cape of Good Hope, and relinquished St. Helena, which we at onee occupied and held until driven out by them in 1672. In 1656 they obtained possession of Calicut from the Portuguese. In 1658 they captured Negapatam, making it, in subordination to Batavia, the head of all their establishments on the Coromandel coast, and expelled the Portuguese from Jafnapatam, their last stronghold in Ceylon. In 1661-4 they expelled them from Quilon, Cochin, Cannanore, Cranganore, and other places on the Malabar coast, and in 1669 from St. Thomé and Macassar.

The following is a list of their settlements submitted by the Dutch Company to the States-General the 22nd October, 1664:—

Amboyna, with its subordinate islands, which supply the whole world with spice.

The Banda islands, which produce nutmeg and mace.

Paulo Roon, ceded to the English, but not given over to them.

Ternate and other Moluccas.

Maeassar and Mando in Celebes.

Timor.

Bima in Sumbawa, rice and sopan-wood.

In Sumatra, Jambce, Palembang, and Indraghiri. Acheen (*i.e.*, "City of Peace") is given up.

Malacca, Tenasserim, and Junkceylon.

(The factory in Siam had been withdrawn, likewise the one at Legore).

Tonquin, a factory.

In Aracan, for rice and slaves.

In Coromandel, Pulicat, Negapatam, and Masulipatam.

In Pegu, factories at Ava and Sirian.

In Bengal, "Hughley," Cossimbazaar, Dacca, Potna, "in command of a great trade in silk, cotton goods, saltpetre, sugar, rice, &c."

In Orixa, a factory for rice and other provisions supplied for Ceylon.

Ceylon, one of the most important possessions of the Company,—garrisons at Columbo, Point de Galle, Negombo, Manaar, and Jafnapatam.

Tuticorin, a good trade in cotton goods and pearls.

In Malabar, Cochin, Cranganore, Quilon, Cananore,—the Zamorin of Calicut and other princes have contracted with the Company to sell all their pepper to them at Porca, where they had ordered the English to withdraw.

In Guzerat, a factory at Surat, in charge of the trade of Hindostan, "which is very considerable," with dependent posts at Ahmedabad and Agra.

In Persia, Gombroon and Ispahan.

In the Persian Gulf, Bassorah.

In Arabia, Mocha had been recently given up.

The Cape of Good Hope.

The island of Mauritius.

Java, where was their capital Batavia, producing prodigious quantities of riee, sugar, fruits, &c.

In 1672 they took from us St. Helena, which we had occupied from 1651. Before the latter date they had held the island from 1600.

In 1677 William of Orange married the Princess Mary of England,

In 1682 the Dutch expelled our factory from Bantam, which forced us also to abandon our factories dependent on it in Siam and Tonquin, and at Amoy, and other places in the more eastern Indies.

In 1689 William of Orange became King of England.

In the great war from 1781 to 1811, Holland lost all her colonies to us; but in 1813, when it was restored to the House of Orange, most of them were given back by us; and Java in 1816, and Sumatra in 1824, in exehange for Malacca.

The Dutch would have been unable to maintain their independenee without the trade of the East, and when they lost it they rapidly sank into their present state of commereial and political lethargy and decay. They lost it entirely through the narrow and exclusive spirit in which they pursued it. Although their enterprise ended in the formation of an empire, their sole object at first was to engross the spice trade of the Moluccas and Banda Islands. With this object they made the mistake, and long persisted in it, of establishing the seat of government in the remote island of Antigua; and it was not until John Pietresoon Koen, on his own authority, transferred it to Java, and in 1619 founded the city of Batavia, that the supremacy of the Dutch in the Indian Archipelago was secured. Yet still the sordid object of their pursuit, the monopoly of the spice trade, continued to injure their credit, and gradually undermined their power. They suffered still more through the egotistical national spirit, characteristic of all the Teutonic races, which was suffered to overrule the European policy of the United Provinces.

If the Hollanders, instead of secluding themselves within their own stagnant marshes, had opened up their canals to German commerce, and their Indian colonies to German emigration, and had identified German interests with their own, they would have maintained the supremacy of the seas against us, and supplanted us in the empire of the East. They stood up boldly against us, and were hard to beat down; but they were too few, and their great eastern commerce, even with the possession of Java, had too precarious a basis of territorial sovereignty, for it to have been possible for their power to survive a protracted struggle with England. It was fortunate, indeed, for England, that their early opposition to us at Bantam and Amboyna, led to our transferring the seat of the English East Indian Company's Government from the Indiau Archipelago to the continent of India, through the inevitable conquest of which we at last secured a position which at once gave us the command of the commerce of the East, from Constantinople to Pekin, and from Australia and New Zealand to the Cape of Good Hope. India is in fact the geographical, commercial, and political keystone of the whole arch of land which spans the waters of the great southern ocean of the eastern hemisphere.

The contemporary works of travel connected with the early settlement of the Dutch in the East, will be referred to among the books relating to the Factory Period of the English East India Company.

The English in India.

The first English attempts to reach India were by the north-west passage. In 1497, Henry VII. fitted out two vessels, under the command of John Cabot, to try and pierce this passage to India. He failed, but on his way back fell in with Newfoundland aud the Continent of North America. Corte Real, the Franklin of Portugal, in attempting the passage in 1500, discovered Labrador. In 1497, Sebastian Cabot, the son of John Cabot, obtained sanction for a charter from Edward VI., which was confirmed by Philip and Mary, 1554-55, for "the discovery of lands, countries, and isles not before known to the English," by this passage; and on the 10th of May, 1553, Sir Hugh Willoughby, with Richard Chancelor, second in command (Stephen Borwogh, of "Burrough's Strait," was Master under Chancelor), sailed on their adventurous quest. They failed, and Sir Hugh and all his crew perished of cold in a river or haven called "Arzina" (Warsina), in Lapland, but Chancelor arrived at a port in the Northern Ocean, where Archangel was afterwards (1584) founded; and thus was Russia practically first discovered by Western Europe. Martin Frobisher attempted twice to discover the N.W. passage in 1576 and 1577, in the latter year on behalf of "the Company of Cathay;" and John Davis conducted three expeditions for its discovery, between 1585 and 1587, under the patronage of the London Company, entitled the "Fellowship for the Discovery of the N.W. Passage." George Waymouth's attempt was made in 1602. Henry Hudson's three voyages were made, 1607-8-9; William Baffin's in 1612-13-15-16; and Vancouver's, 1791-95; and it was not until after Parry, Ross, and Franklin's attempts, that the N.W. passage was at last discovered by Maclure in 1850.

Chancelor travelled from Archangel to the Court of the Grand Duke of Moscow, and laid the foundation of the Muscovy, or Russian Company (as the "Company for the Discovery of Lands not before known" was henceforth called) for carrying on the overland trade between India, Persia, Bokhara, and Moscow. In 1557, Anthony Jenkinson and Robert Johnson sailed to Russia to explore the route of this trade. From Moscow they went to "Nyse Novogorod," and down the Volga to "Ozan," whence they went on to Astrakan and to "Boghar" (Bokhara), from which place Jenkinson returned to Moscow in 1559. In 1561 he was sent out again to explore the route through Persia, and, travelling by Moscow and Astrakan, he got by way of Derbent so far as Casbin, where he met a number of native merchants from India. Chenier's expedition followed, and after that Edwards' expedition was sent out in 1565, of which Laurence Chapman is the narrator. Peter the Great was very anxious to secure the trade with India through Russia, and in 1717 sent Beckewitz, the son of a Circassian prince, to explore the Amu Darya; and in 1723 employed Peter Henry Bruce (Travels, London, 1782) to survey the Caspian. John Elton (Hanway, 1753) was also employed to survey the south-eastern frontier of Russia, and sent home so enthusiastic an account of the new opening by this route for English trade with India, that, in spite of the opposition of the Turkey Company, which had been founded in 1581, and the East India Company, an Act was passed permitting the importation of silk and other Eastern commodities through Russia. But, owing to Elton's success with the Persians, the envy and jealousy of the Russians were excited. Jonas Hanway was sent from St. Petersburg in 1743 to arrange the differences between them. It was in vain, and in 1746 the Russian Government formally announced that the English would no longer be allowed to pass through their territories for the purposes of trade with India.

The Turkey and Levant Company (founded in 1581) in the prosecution of their trade, having sent merchants from Aleppo to Bagdad, and thence down the Persian Gulf, and having purchased Indian articles at Agra, Lahore, and Malacca, greatly stimulated the desire then prevailing in England for participating with Portugal in the direct trade with India by sea. In 1577, Sir Francis Drake fitted out four ships, with which he sailed through the Straits of Magellan, and returned home (his expedition reduced to a single ship) by the Cape of Good Hope. In the course of his voyage he touched at Ternate, one of the Moluccas, the king of which island agreed to supply the English nation with all the cloves it produced, and was thus the first person to open direct commercial intercourse between England and the East Indies, as well as the first Englishman to circumnavigate the globe. The first Englishman who actually visited India was Thomas Stephens in 1579, unless there be any foundation in fact for the statement of William of Malmesbury, that in the year 883, Sighelmus, bishop of Sherborne, being sent by King Alfred to Rome with presents to the Pope, proceeded from thence to the East Indies to visit the tomb of St. Thomas at Maliapur, and brought back with him a quantity of jewels and spices. Stephens was

educated at New College, Oxford, and at Goa was the rector of a College in Salsette. His letters to his father are said to have roused great enthusiasm in England to trade directly with India. Accordingly, in 1583, three English merchants, Ralph Fitch, James Newberry, and Leedes, and some others, went out to India, overland, as mercantile adventurers. The jealous Portuguese threw them into prison at Ormuz, and again at Goa. At length Newberry settled down as a shopkeeper at Goa, and Leedes entered the service of the Great Mogul; and Fitch, after a lengthened perigrination in Ceylon, Bengal, Pegu, Siam, Malacca, and other parts of the East Indies, returned to England.

In 1586, Captain Thomas Cavendish, following Drake's exhmple, commenced his circumnavigation of the world by the Strait of Magellan and the Cape of Good Hope, touching at the Ladrones on the way.

In 1587, the Spaniards being about to invade England, a strong fleet was sent out under Drake, to annoy their trade and that of the Portuguese, and among the ships of the latter seized by him was the *St. Philip*, the first Portuguese carrack coming from the East Indies the English had ever taken. The papers of this vessel afforded so much information as to the value of the Indian trade, that they are considered to have at last fixed the determination of the English to establish direct communication with India.

Early in 1588, the Spanish Government complained to Queen Elizabeth of Drake and Cavendish having infringed their divine rights by sailing round the globe; to which Elizabeth haughtily replied that what it was lawful to Spaniards to do was lawful to Englishmen, "since the sea and air are common to all men." The Spaniards having in the same year sent the "Invincible Armada" to conquer these islands, it was defeated and scattered to the four winds, July 29 to August 7.

In 1591, some merchants of London fitted out three ships—the *Penelope*, *Merchant Royal*, and *Edward Bonaventure*—under the command of George Raymond and James Lancaster, for trading in the East, and harrying the Spaniards and Portuguese. The expedition came to a bad end, and it was only after many grievous adventures that Lancaster at last returned home without his ship.

In 1592, some English privateers captured the great Portuguese carrack, the "*Mother of God*" ("Madre de Dios") and brought her into Dartmouth, when it was found that her principal cargo, after the jewels, consisted of aloes, ambergris, gum benjamin, cloves, cinnamon, cocoa-nuts, camphor, civet, ivory, ebony, frankincense, ginger, galangal, hides, musk, myrobalans, mace, nutmeg, pepper, and porcelain vessels, raw silk and silk stuffs, and other piece goods, taffetas, sarcanets, cloth of gold, calicoes, lawns, quilts, carpets, canopies, and various other rich commodities. There was also found in her the notable register or "Matricola" of the whole government and trade of the Portuguese in the East Indies, on which the memorial of the promoters of the London East India Company, to Queen Elizabeth in 1599, was principally founded.

In 1596 Sir Robert Dudley fitted out three ships, under the command of Captain Benjamin Wood, for the Indian and Chinese trade; but the expedition was very unfortunate, not one of the company ever having been heard of again.

In 1599, the Dutch, who had now firmly established their trade in the East, having raised the price of pepper against us from 3s. per lb. to 6s. and 8s., the merchants of London held a meeting on the 22nd September, at Founder's-hall, under the Lord Mayor, and agreed to form an association for the purpose of establishing direct trade with India. Queen Elizabeth also sent Sir John Mildenhall by Constantinople to the Great Mogul to apply for privileges for the English company, for which she was then preparing a charter; and on the 31st December, 1600, the English East India Company was incorporated by Royal Charter under the title of "The Governor and Company of Merchants of London trading to the East." The early voyages of the Company, "Separate" and "Joint" Stock, have already been enumerated in the body of my "Report in the old Records," and I now proceed at once to trace out the settlement of the Company's factories in the East Indies.

The Factories.

One of the documents connected with the Company's application for a charter was a memorandum distinguishing the countries in the East Indies to which the Spanish-Portuguese had trade from those in which trade might be freely opened by the English. Among the latter they name—

"The Isle of Madagascar or San Lorenzo, upon the backside of Africa."

"The kingdom of Orixa, Bengala, and Aracan."

"The rich and mightie kingdom of Pegu;" and Jungalaon, Siam, "Camboia," and "Cauchinchina."

"The most mighty and wealthy empire of China."

"The rich and golden island of Sumatra;" and "Java Major," "Java Minor," and Baly; Borneo, Celebes, Gilolo, and Os Papuas.

"The long tracte of Nova Guinea and the Isles of Solomon."

"The rich and innumerable islands of Malucos, and the Spicerie, except the two small islands of Tidore and Amboyno;" Mindinao and Calamines, "and the greate and fmall Lequeos."

"The manifold and populos sylver islands of the Japones;" and "the country of Coray, newly discovered to the north-east."

Sir Foulke Grevil, in replying to Sir Francis Walsingham's demand for "the names of such kings as are absolute, and either have warr or traffique with the Kinge of Spaigne," begins "in Barbarie with the Kingdoms of Fess and Morocco, and continues all round the coasts of Africa to "Sues" at the top of the Red Sea—"in the bottom of this sea." Then he goes round the peninsula of Arabia to Ormuz, and on through the countries beyond the Persian Gulf, to "the Kingdome of Cambaia, which is the fruitfullest of all India, and hath exceedinge greate trafficque." Then he passes in review "the countrie of the Malabars," ("who are the best souldiers of India,") subdivided into the five kingdoms of Baticola, Cochin, "Chananor" Choule, "Coulon," and "Caléchut." Beyond the Malabars "is the Kingdome of Narsinga," "then the Kingdome of Orixen and Bengolen," "as also of Aracan, Pegu, Siam, Tanassaria, and

Queda." The island of Sumatra or Taprobana is possessed by many "Kynges, enemies of the Portugals; the chief is the Kinge of Dacham, who besieged them in Malacca, and with his gallies stopped the passage of victualls and trafficks from China, Japan, and Molucco." "The Kynges of Acheyn and Tor are in like sorte enemies of the Portugalls." "The Philippines belonged to the Crowne of China, but, abandoned by him were possessed by the Spaniards, who have traffique there with the merchants of China." "They trafficque also with the Chinois at 'Mackau' and Japan." "And, lastly, at Goa there is great resort of all nations from Arabia, Armenia, Cambaia, Bengala, Pegu, Siam, Molucca, and China, and the Portugals suffer them all to lyve there, after their own manners and religions; only for matter of justice they are ruled by the Portugal law." This letter of Foulke Grevil affords an admirable bird's-eye view of the political and commercial relations of the countries along the shores of Africa and Asia at the period of the first appearance of the English Company's ships in the Eastern Seas.

A list of the principal imports from the East Indies into Portugal and Holland was also prepared by John Chamberlain for the Company, and proved most useful to them. As it has never been published before, I give it here entire, being indebted for it to Mr. Noel Sainsbury of the Public Record-office, who has had it extracted from the "East Indies" series Vol. I No. 19.

The Comodities of the Este Indies.

Sinemonde.
Peper case.
Pepper callycowe.
Longe peper.
Cloves.
Maces.
Nutmegges.
Ginger.
Mirabolanes in conserve.
Mirabolanes drye.
Grene ginger.
Nutmegges in conserve.
Peper in pickell.
Muske and syvitt.
Amber greise.
Amber blacke.
Benjamin fyne.
Lingun alloes.
Blew Indea.
Lacrya to die withall.
Hard wax.
Turbythe.
Radix China.
Alloies sicotrinan.
Spignard.
Oyle of maces.
Synamon water.
Camfyer.
Burrassie.
Gallingale.
Cardamente.
Red sandes.
White sandes.
Tamornydes.
Myrre.
Balsamum.
Momya.
Masticke.
Rubarbe.
Goom Appopauax.
Gum selapin.
Gum elemne.
Castorium.
Opium.
Tacamihaca.
Tutia.
Boill.
Indies nuttes.
Silke in clothe.
Silke rawe.
Clothe of Erva.
Paynted clothes.
Callycow clothe.
Oanaynemas bengallas — linen clothe of finer sort then cally-cow.
Clothe of goulde.
Pusselanas — certain dishes and plates so-cawled.
Targattes.
Ffanes.
A stone called bazar.
Diamondes.
Rubyes.
Saffiers.
Esmeraldes.
Pearles greate.
Seide of pearle.
Turkeis.
Callimas armaticus.
Insence.
Zedoaraya.
Cabubes.
Quiltes of silke.

The English were everywhere opposed from the first, as the Dutch had been, by the Portuguese; but James Lancaster succeeded, in his first voyage, in establishing commercial relations with the king of Acheen in 1602, and with Priaman, and the Moluccas, and at Bantam, where he settled a factory, or "house of trade," in 1603. In 1604 the Company undertook their second voyage, commanded by Sir Henry Middleton, who extended their trade to Banda and Amboyna. The success of these voyages was so great that it induced a number of private merchants to endeavour to obtain a participation in the trade, and in 1606 James I. granted a licence to Sir Edward Michelborne and others to trade "to Cathay, China, Japan, Corea, and Cambaya." Michelborne, however, on arriving in the East, instead of exploring new sources of commerce, as the East India Company were doing, followed the pernicious example of the Portuguese, in plundering the native traders among the islands of the Indian Archipelago. He in this way secured a considerable booty, but he brought disgrace on the English name, and much hindered the Company's business at Bantam. In 1608, Captain D. Middleton, in command of the fifth voyage, was prevented by the Dutch from touching at Banda, but succeeded in obtaining a cargo at Paloway. In this year also, Captain Hawkins proceeded from Surat as envoy from James I. and the East India Company to the Court of the Great Mogul, and was graciously received by the Emperor Jehanghir, and remained three years at Agra. In 1609, Captain Sharpey, of the fourth voyage, obtained the grant of the free trade of Aden. In this year also the Company constructed their Dockyard at Deptford, and this was the beginning, observes Sir William Monson, of the "increase of great ships in England." In 1611, Sir Henry Middleton arrived off Cambay, and resolutely fought the Portuguese, who tried to beat them off, and obtained some important concessions from the native powers. In 1610-11 also, Captain Hippon, commanding the seventh voyage, succeeded in establishing an agency at Masulipatam, and in Siam and Patania, and a factory at Peltapolee, and Sir Henry Middleton settled agencies also in the Tecoo Islands off the coast of Sumatra, and at Mocha; and Captain Saris, commanding the eighth voyage, at Firando in Japan, but the Company were successfully prevented by the Dutch from establishing a trade with Pulicat.

In 1812, the Company's fleet, or the tenth voyage, under the brave Captain Best, was attacked off Swalley, the port at the mouth of the River Tapti, of Surat, by an overwhelming force of Portuguese, and after four successive engagements utterly defeated the Portuguese, to the great astonishment of the natives, who had hitherto considered them to be invincible. The first fruit of this decisive victory was the settlement of a factory at Surat, with subordinate agencies at Gogree, Ahmedabad, and Cambay. Trade was also opened with the Persian Gulf. But the chief trade of the Company was still with the Indian Archipelago, and though Surat was their greatest emporium in India, it long continued subordinate to Bantam. A temporary agency was at this time opened at Cambello, in the island of Amboyna. In 1614, an agency was established by Mr. Edwards, of the Surat factory at Ajmere. In

1615, Sir Thomas Roe was sent out by James I. as ambassador to the Court of Jehanghir, and succeeded in placing the Company's trade in the Mogul dominions on the most favourable footing. In 1616 we had factories at Calicut and Cranganore; and the Danes established factories at Serampore and Tranquebar, which were surrendered to us in 1808. In 1617 possession was obtained of the islands of Pulo Roon and Rosengyn, and a factory was established at Macassar; and at this period the Company had factories in the Archipelago, also at Acheen, and Ticoo in Sumatra, at Jaccatea and Jambee in Java, at Banda, at Succadania and Banjermassin in Borneo, at Patania in the Malay Peninsula, and in Siam;—all, together with those in India and Japan, being subordinate to Bantam, the factory at Surat being the chief seat of the Company's Government in Western India, until the Presidency was transferred to Bombay in 1685-87. In the year 1617 the Dutch also established factories at Surat and Broach. In 1618 the English established a factory at Mocha, while the Dutch compelled us to resign all pretentions to the "Spice Islands." In this year also, the Company failed in its attempt to open a trade with Dabul, Baticaloe, and Calicut, through the want of sincerity on the part of the Samorin. In 1619 the treaty with the Dutch, to prevent disputes between the English and Dutch companies, was ratified, but came to nothing. Up to this time the English company had not any portion of territory in sovereign right in the Indies, excepting in the island of Lantore or Great Banda. This island was governed by a commercial agent of the company, who had under him thirty Europeans as clerks, overseers, and warehousemen; and these, with 250 armed Malays, constituted the only force by which it was protected. In the islands of Banda and Pulo Roon and Rosengyn the company possessed factories, in each of which were ten agents. At Macassar and Acheen also they possessed factories or agencies, the whole being subordinate to Bantam. Such was the precarious situation of the East India Company in the Archipelago at the commencement of their long struggle for commercial equality with the Dutch, whose ascendancy in the East was already established on the basis of territorial dominion and authority. In 1619 also, the Company was permitted to settle a factory and build a fort at Jasques in the Persian Gulf. In 1620 the Dutch, notwithstanding the Treaty of Defence concluded the previous year, expelled us from Pulo Roon and Lantore, and in 1621 from Bantam. The fugitive factors attempted to establish themselves, first at Pulicat and afterwards at Masulipatam on the Coromandel coast, and were effectually opposed by the Dutch. In 1620 also, the Portuguese made an attack upon the English fleet under Captain Shillinge, but were again defeated with great loss; and from this time the estimation in which the Portuguese were held by the natives of India steadily declined, while that of the English was proportionally raised. In this year also the Company established agencies at Agra and Patna.

In 1622, the English, joining the Persians, attacked and took Ormuz from the Portuguese, and obtained from the Shah Affas a grant in perpetuity of the customs of Gombroon. In this year the Company also succeeded in re-establishing their factory at Masulipatam. On the 17th February, 1623, occurred the "Massacre of Amboyna;" and from this time the Dutch remained masters of Lantore and the neighbouring islands, and of the whole trade of the Indian Archipelago, until these islands were recaptured by the English in the great naval wars which commenced in 1793. In 1624, the English, unable to oppose the Dutch, withdrew nearly all their factories from the Archipelago, the Malay Peninsula, Siam, and Japan. Some of the factors and agents retired to the island of Lagundi in the Strait of Sunda, but were forced, by its unhealthiness, to abandon it.

In 1625-26, a factory was established at Armagon on the Coromandel coast, subordinate to Masulipatam; but in 1628, Masulipatam was, in consequence of the oppressions of the native governor, for a time abandoned in favour of Armagon, which now mounted twelve guns, and had twenty-three factors and agents. In 1629 the factory at Bantam was re-established as a subordinate agency to Surat; and in 1630 Armagon, reinforced by twenty soldiers, was placed under the Presidency of Surat. In 1632 the factory was re-established at Masulipatam, by a "phirmand," known as the "Golden Firman," from the king of Golconda. In 1634, by a phirman, dated February 2nd, the Company obtained from the Great Mogul the liberty to trade in Bengal, without any other restriction than that the English ships were to resort only to Piplay. The Portuguese were this year expelled by the Great Mogul from Bengal. In 1635 an agency was established in Tatta, and Bantam was again raised to an independent Presidency. In 1637 Courten's Company established agencies at Goa, Batticolo, Carwar, Acheen, and Rajapore. Their ships had the previous year plundered some native vessels at Surat and Diu, which disgraced the Old Company with the Mogul authorities, who could not comprehend the distinction between the two companies, and depressed the English trade with Surat, while the Dutch trade greatly increased. In 1638, Armagon was abandoned as unsuited for commerce, and in 1639-40, Fort St. George Madrapatam, was in consequence founded by Francis Day, and the factors at Armagon were at once removed to it. It was made subordinate to Bantam, until raised, in 1653-54, to the rank of a Presidency. In 1640, the Company established an agency at Bussorah, and a factory at Carwar. The Company's trade having now become much extended, their yard at Deptford was found too small for their ships, and they purchased some copyhold ground at Blackwall, which at that time was a waste marsh, without an inhabitant; and there they opened another dockyard, in which they built the largest ship—the *Royal George* of 1,200 tons—yet seen in England. In 1642 the factories at Balasore and Hugly were established, and the first regular despatches were received by the Company from Fort St. George and Balasore from Mr. Francis Day. In 1645, in consequence of the professional services rendered by Dr. Gabriel Broughton, surgeon of the *Hopewell*, to Shah Khan, additional privileges were granted to the Company; and in 1646, the Governor of Bengal, who had also been professionally benefited by Broughton, made concessions which placed the factories at Balasore and Hugly on the most favourable footing. In 1647, Courten's Associa-

tion established their colony at Assada, in Madagascar. About 1650, the East India Company established a factory at Verasheroon. In 1651, the English expelled the Dutch from St. Helena, which the latter had held from 1600. It was taken up by the Dutch from us in 1672, but at once retaken and made over to the East India Company in 1674. It was in this year that the Dutch settled their colony at the Cape of Good Hope. In 1652, Cromwell, feeling that his popularity was waning, and not sure of the army and navy, declared war against the Dutch, on account of their accumulated injuries against the Company.

In 1653 the Company's factory at Lucknow was withdrawn. No record has yet been found of its establishment.

In 1654, by the Treaty of Westminster, the Dutch agreed to restore Pulo Roon to the English Company, and paid them an idemnity of £85,000, and a further sum of £3,615 to the heir and executors of the victims of the "Massacre of Amboyna"—a settlement which gave new life and spirit to the Company's trade, which had at this time, from various causes, but chiefly from the opposition of Dutch, been greatly depressed, and in the Persian Gulf and Indian Archipelago was almost suspended.

In 1655, in the "Masulipatam Consultations" of December 4th, 1655, mention is made of factories and agencies and Dalapadie, in addition to those at Petapolee and Verasheroon already mentioned. In this year also, the Company of "Merchant Adventurers" obtained their charter from Cromwell, to trade with India, but in 1657 united with the original company. In 1656-57 the Dutch established a factory at Chursinah which was taken by us in 1795, given back to the Dutch in 1814-15, and ceded to us by treaty in 1824. In 1658, the company established a factory at Cossimbazaar, and their establishments in Bengal were made subordinate to Fort St. George instead of to Bantam. In 1661 Bombay was ceded to the British Crown. It was delivered up in 1655, and transferred to the East Indian Company in 1668. The seat of the Western Presidency was transferred to it from Surat in 1685-87. At this time the Company's establishments in the East Indies consisted of the Presidency of Bantam, with its dependencies of Jambee and Macassar, and other places in the Indian Archipelago; Fort St. George and its dependent factories on the Coromandel coast and in Bengal; and Surat, with its affiliated dependency of Bombay, and dependent factories at Broach, Ahmedabad, and other places in Western India; and at Gombroon and Bussorah in the Persian Gulf and Euphrates Valley.

In this year, 1661, also, the factory of Billiapatam was founded. In 1663, the factories which had been established at Patna, Balasore, and Cossimbazaar, were ordered to be discontinued, and purchases made only at Hugly. In 1664, Surat was pillaged by Sivajee, but Sir George Oxenden bravely defended the English factory; and the Mogul Emperor, in admiration of his conduct, granted the Company an exemption from customs for one year.

In 1667, Pulo Roon was ceded to the Dutch by the treaty of Breda. It was an early possession of the Company, from which they were driven by the Dutch in 1620, who continued to hold it in spite of their obligations to surrender it under the Treaty of Westminster, 1654, until about 1663, Major Willoughby was appointed Governor from England. But in 1664, the Dutch again seized it, and held it until it was finally ceded to them. In 1668 a factory was established at Vizajapatam. In 1672 factories were ordered to be established at Tonquin and Tywan, and in Siam, Japan and China. A vessel was sent to Japan, but in consequence of the King of England having married a princess of Portugal (Charles II. married Catherine of Braganza, 1661-2) they were refused permission to trade. They then proceeded to Macao, but were greatly hindered by the intrigues of the Portuguese; and an attempt to open trade with Formosa proved altogether unsuccessful. In 1673 the Hooblee factory, subordinate to Surat, was again attacked by Sivajee. In 1674 factories were settled at Cuddalore and Thevnapatam; and between 1672 and 1674 the French city of Pondicherry was founded by Martin. In 1677 the Javanese, at the instigation of the Dutch, sacked the Company's factory, at Bantam, and assassinated the agent, in consequence of which the factory books were closed and conveyed to the Court of Directors. In this year also, the Company's factory at Madapalam is first mentioned. In 1678 permission was obtained for settling a factory at Torquin, and 1679 a factory was established at Amoy. In 1681 Bengal was separated from Madras, and Mr. Hodges appointed "agent and governor" of the Company's affairs "in the Bay of Bengal, and of the factories subordinate to it, as Cossimbazaar, Patna, Balasore, Malda, and Dacca. A corporal of approved fidelity, with 20 soldiers, to be a guard to the agent's person at the factory at Hooghly, and to act against interlopers." (See 1687 and 1698.) In 1682 Bantam was taken by the Dutch, and the English driven out, in consequence of which the Company was obliged to withdraw its factories at Tonquin, Amoy, Siam, and other places in these parts, subordinate to Bantam. In 1684 we were expelled from the whole island of Java, but it was not until the 1817 that we formally withdrew from Bantam. In 1682-84, Keigwin's remarkable insurrection at Bombay caused some anxiety. In 1683 a factory was settled at Tillicherry, and that at Cuddalore was definitely established. Fort St. George (Madras) was in this year (1683-84) constituted a Presidency. In 1684 Sir John Child was made "Captain General and Admiral of India," and Sir John Wyborne," Vice-Admiral and Deputy Governor of Bombay;" and in 1685-87 the seat of the presidency was transferred from Surat to Bombay. In 1685 a factory was established at Priaman, an island off Sumatra, and fortified. An island on the Ganges was also fortified; and the factory at Masulipatam was temporarily dissolved. Anjengo was probably first occupied in this year, but its early history is obscure. In 1686, the factory at Hugly was much oppressed by the Mogul Governor of Bengal, and the Company's business in India generally suffered much from the wars of the Mogols and Mahrattas. Sir John Child was, therefore, appointed "Governor General," with full power in India to make war or peace with the Mogols and Mahrattas, and ordered to proceed to inspect the Company's possessions in Madras and Bengal, and arrange for their safety.

On the 20th of December the Company's agent and council quitted the open factory at Hugly, and retired to Chuttanuttee.

Tegnapatam (Fort St. David) was first settled in this year (1686), and definitively established in 1691-92. In 1687 the Company retired from all its factories and agencies in Bengal to Madras, but established the settlement of Fort York at Bencoolen. Fort Marlborough they built in 1719. In 1688 the French obtained Chandernagore from the Emperor Aurungzebe. In 1689 the Company's factories at Vizagapatam and Masulipatam were seized by the Mogols, and the factors massacred. It was in this year that at last the Company determined to consolidate their position in India, on the basis of territorial sovereignty, in order to acquire the political status of an independent power in its relations with the Mogols and Mahrattas. To this end they formed the following resolution for the guidance of the local governments in India :—"The increase of our revenue is the subject of our care, as much as our trade; 'tis that must maintain our force when 20 accidents may interrupt our trade; *'tis that must make us a nation in India;* without that we are but a great number of interlopers, united by His Majesty's Royal Charter, fit only to trade where nobody of power thinks it their interest to prevent us; and upon this account it is that the wise Dutch, in all their general advices that we have seen, write ten paragraphs concerning their Government, their civil and military policy, warfare, and the increase of their revenue, for one paragraph they write concerning trade."

Sir John Child died this year at Bombay. In 1691-92, the factory at Tegnapatam, first settled in 1686, was fortified and called Fort St. David; and the factory at Baroach was dissolved.

In 1693, the Company spent £90,000 in bribing the Privy Council to renew their charter, and prevent the incorporation of the new "English Company." In 1694, Anjengo was fortified from Bombay, and became famous as the birthplace of Orme, and of Mrs. Draper, Sterne's Eliza.

In 1698, in spite of all their bribes, "the old East India Company lost their business against the new Company by ten votes in Parliament, so many of their friends being absent, going to see a tiger baited by dogs." (Evelyn's Diary, March 5th.) The New Company was called "the English East India Company," in contradistinction to the Old or "London Company." On this "the Old Company" exerted itself "with a true Roman courage," as one of their official letters to their servants in India states. At Madras and elsewhere all their old factories and stations were resumed, so as to exclude the new Company, and Bengal was again made independent of Madras.

In 1698-99 the Old (London) Company obtained a grant of the towns of Chuttanuttee, Govindpore, and Calcutta, from the Great Mogul, and began to construct Fort William, which to this day is the only stronghold the English possess in India; and from this period Bengal was considered a separate Presidency.

In 1698, the new or English Company ("The General Society trading to the East Indies") established a factory in Borneo.

In 1708, a factory was established at Anjeram; and in 1719 Fort Marlborough was built.

In 1702-8, the union of the Old (London) and New (English) Companies was effected, under the name of "The United Company of Merchants trading to the East Indies."

In 1707 also, Aurungzebe died after a reign of upwards of 50 years, and from the period of his death commenced those troubles which gradually broke up the Mogul Empire, and paved the way for the conquest of India by the East India Company.

With his death and the union of the two Companies the chronicle of the English factories ends, and the history of the English conquest begins.

I will conclude this period, therefore, with the enumeration of the various factories which were established by the English at different periods, from the commencement of their trade to the East until the union of the two Companies in 1708. Those mentioned in the deed of union are shown in italics.

In the Red Sea.

Aden and Mocha.

In the Persian Gulf and Persia.

Bushire, Ispahan, Gombroon, and Shiraz.

On the Western Side of India, or Coasts of Cambay and Malabar.

Cutch, *Bombay*, Cambay, Rajbay, *Ahmedabad*, Rajafiore, Baroda (Brodera), *Carwar*, *Baroach*, Baticaloe, *Surat* and *Swully*, Onore, Barcelore, Cranganore, Mangapore, Cochin, Durmapatam, Porca, Cananore, Carnoply, *Tellichery*, Quilon, *Calicut*, *Anjengo*.

On the Eastern Side of India, or Coast of Coromandel.

Tuticorin, *Masulipatam*, *Porto Novo*, Verasheroon, *Cuddalore*, Ingeram, *Fort St. George* (Madras), *Vizagapatam*, Pulicat, Bimlipatam, *Pettipole*, Ganjam, *Madapolam*, *Fort St. David* (Tegnapatam).

In Bengal.

Balasore, *Lucknow*, *Fort William*, Chuttanuttee (not yet known as Calcutta), Bramporo, *Hughley*, *Agra*, *Cossimbazaar*, Lahore, *Rajahmal*, *Malda*, *Patna*, *Dacca*.

On the Malay Peninsula.

Siam, Cochin China, Pegu, Patany, Quedah, Johore, Cambodia, Ligore.

On Sumatra.

Acheen, Jambee, Passaman, Bantam, *Sillebar*, Japara, Tecoo, Jacatra, *Fort York*, *Bencoleen*, *Indiapore*, and *Tyamong*.

On Borneo.

Banjarmassin and Succadana.

On Celebes.

Macassar.

In the Moluccas.

Factories in Banda, Amboyna, and Pulo Roon.

In the China Seas.

Tonquin, *Pulo Condore*, Amoy, Tywan, Macao, Chusan, Magindanao.

In Japan.

Firando.

In the Atlantic Ocean.

St. Helena.

Such was the Factory Empire of the East India Company.

Books on the Factory Period.

Jan Hugo van Linschoten travelled in India from 1583 to 1589, and Philip Baldæus about 1660; and the "Voyages into the East and West Indies"

of the former, and the "Description of the Coasts of Malabar and Coromandel" of the latter, are two invaluable books for the information they give of the early days of the Dutch in the East, and their struggles with the Portuguese.

In 1563, Cæsar Frederick, a Venetian merchant, went by way of the Persian Gulf to India, and on to Pegu; and the accounts he gives of his travels was translated into English by Thomas Hichoch in 1588, under the title of "Voyage and Travaill into India, the Indies, and beyond the Indies." He describes Cambay, where the commercial supremacy of the Portuguese was acknowledged, and Ahmedabad and Goa. He gives a very detailed account of the commerce of Pegu, which he visited in 1568. It had previously been visited by Antonio Correa, who, shortly after the occupation of Malacca by the Portuguese, was despatched thither with the view of establishing trade with Burmah. It was subsequently (1583) visited by Gasparo Balbi, and his "Viaggio dell' Indie Orientale" and Cæsar Fredcrick's narratives are the best notices we possess of this country, until the publication of the modern works of Symes and Phayre.

Pietro della Valle travelled in Persia in 1614-22, and Olearius was secretary to the Duke of Holstein's embassy to Russia and Persia in 1633-39; but neither of their narratives trench on the proper ground of the Dutch and English factory period in India.

Mandelslo accompanied the Duke of Holstein's mission to Russia and Persia, to which Oleaurius was Secretary, in 1633-39. From Bunda Abass he went on to Surat, and visited also Baroach (Brodera), Ahmedabad, Cambay, Lahore, and Vezeapour, returning from Surat to Denmark, where he landed May 1, 1340. His travels, translated by John Davies, were published in England, in one volume, with Olearius's account of the Duke of Holstein's mission in 1669, and give a most interesting account of our factory at Surat, and of the factors' manner of life there. They were the inventors of "punch" (in Hindustani, *panch*) so-called from the five ingredients—spirit, lime or lemon juice, sugar, spice, and water—used in its composition.

Sir Thomas Herbert, of the brilliant Pembroke family, travelled in the East Indies from 1626-30, and his book was published in 1634.

Henry Lord's "Display of the Sect of Banians," and "Religion of the Parsees" were published in 1630.

The "Peregrinacion de la Mayor Parte del Mondo" of Don Pedro Sebastiono Cubero was published at Saragossa in 1688. He set out about 1650, from Moscow, with the Russian Ambassador to the Court of Persia. From Ormuz he sailed to "Damayn," and Surat, and Goa, where he found the capital of the Portuguese Asia in a state of miserable decay, and its trade almost gone since the "perfidious heretics," the Dutch, English, and Swedes and Danes had carried it off. From Goa he sailed to Masulipatam, and thence to Malacca, already in the hands of the Dutch, and on to Manilla, where he took ship across the Pacific to Mexico.

Sir John Chardin travelled in Persia and the East Indies from 1664 to 1670; and the first part of his travels was published in 1686 (London), and the 2nd and 3rd in 1711 (Amsterdam).

Edward Terry's "Voyage" was published in 1655, and gives a most interesting account of Surat and Swally, and of Tom Convat's visit to Surat.

John Ovington's "Voyage to Surat" was published in 1696.

John Fryer, surgeon to the Company, travelled in Persia and India from 1672-81, and his book, published in 1698, is the most delightful work ever published on India, and invaluable for its pictures of factory life, and graphic account of the condition of the people of India at that time.

Cornelius Le Bruyn, "Voyage to the Levant," of which an English translation was published in 1702, although it never extended to India, and scarcely, therefore, comes within the sdope of the present Report, is here mentioned on account of the excellence of its copper-plate illustrations, numbering 300, of the people and cities, and scenery of the countries he describes, and particularly of the ruins of Persepolis and other antiquarian remains in Persia.

Jean de Thevenot (1689) travelled in the East in 1655-64; Francois Bernier (1670) lived at the Court of Arungzebe for twelve years (1658-70), and accompanied that monarch to Cashmere; and Tavernier (1678-79) travelled in India from 1663-69; and the works of these three Frenchmen rank among the most valuable books of travel that have ever been published on India. The other two are those of Jacquement and Heber. Victor Jacquement (1841-44) travelled in India from 1828-32, and Bishop Heber (who, before going to India, had visited Germany, Russia, and, the Crimea) from 1823 to 1828; and his "Journal" is one of the most instructive and important works ever given to the world on India. It has never been excelled.

Giovanni Francesco Gemelli-Careri of Naples, in his narrative, "Giro del Mondo," published in 1699, of six years' travel round the world, notices that at that date the remains of the Portuguese conquests in Asia were so inconsiderable as scarcely to defray their own expenses.

Sir Thomas Roe's admirable account of his visit to the Mogol Court in 1615-18, originally given in Purchas, has since been published separately.

Mr. Markham (1877), in his volume on Lancaster's voyages, has given abstracts of the journals of voyages to the East Indies by the Company's commanders, during the 17th century, which before were only to be read in Purchas. It is one of these works to which I have been greatly indebted in preparing this note. The others to which my acknowledgments are due being:—Faria y Gonsa's "Asia Portuguesa," 1666; De Barros' "Decades," 1552; "Recueil des Voyages de la Compagnie des Indies Orientales des Hollandois," 10 vols. 12mo., 1730; Alex. Hamilton's "New Account of the East Indies," 1727; Milburn's "Oriental Commerce," 1813; Bruce's "Annals of the East India Company," 1810; Eden's "History of Travayle," 1577; Peter Auber's various works on the East India Company, *circa* 1826; James Mill's "History of British India," 1817; and A. Anderson's "History of Commerce," 4 vols. folio, 1787 (published anonymously). I have also derived invaluable assistance from the three volumes of the "Calendar of State Papers," on the "East Indies," edited by Mr. Noel Sainsbury of the Public Record Office; James Forbes' "Oriental Memoirs, 1834;" and Philip

Anderson's delightful book, "The English in Western India," 1856; it is well worth republication, with the articles published subsequently to it the "Bombay Quarterly Review;" and Mr. Talboys Wheeler's "Madras in the Olden Time," 1862; and "Early Records of British India," 1878.

The Conquest.

The period of the conquest of India by the Company is beyond that covered by the general mass of the old miscellaneous records now reported on, and all that is necessary to be given under the present head is an inventory of the Company's conquests, in illustration of the original firmans and numerous copies of firmans ("translates of phirmands") enumerated in the body of the "Report on the Old Records." It will be convenient, however, to give a slight prefatory sketch of the political history of India, from the appearance of the Portuguese in the Eastern Seas to the close of the Company's rule. Messrs. Tidler and Craufurd's "Memorandum" of 1873-75 affords an admirable clue to the later records relating to the period from 1708-9 to 1858, when the East India Company was extinguished, and the administration of the British Indian Empire was transferred to the Imperial Crown of the United Kingdom.

When the Portuguese first appeared in India, the seventh Afghan dynasty of the House of Lodi (1450—1526) was the paramount power in Hindustan, while in the Deccan the Hindu kingdom of Bijanagar, known to the earlier European travellers and settlers in India as "the kingdom of Narsinga," still maintained its independence. A number of petty Hindu states also flourished along its further borders, of which Calicut under its Zamorins was one. Baber, the founder of the Mogul Empire, the son of the governor of Ferghana, and descended from both Chenghiz Khan and Tamerlane, seized on Cabul in 1504, conquered the Punjab in 1518, and met and overthrew Ibrahim Lodi on the plain of Panipat, March the 5th, 1526.

It was under the fourth Afghan dynasty of the House of Khilji that the Mahommedans invaded the Deccan in 1300. The Amirs established in the Deccan revolted against the House of Tuglak, the fifth Afghan dynasty of Delhi, in 1347, when Zuffir Khan, the Afghan, founded the great Brahmini dynasty, which ruled at Kilburga from 1347 to 1526. After this rebellion the ruler of Delhi never again crossed the Nerbudda into the Deccan until the reign of Akbar. (See history.) In 1526 the Brahmini kingdom became divided into the kingdoms of Bijapur, Baidar, Ahmednagar, and Golconda, and in 1565 the kings of Golconda, Ahmednagar, and Baidar, Bijapur united against the Hindu kingdom of Bijanagar, and divided the chief portions of it between them, the remainder falling to the Naiks, Zemindars, and Polygars of the Madras Presidency. It was then that Mysore became independent.

It was during the wars caused by the efforts of Akbar and his successors to reduce the kingdoms of the Deccan to subjection, that the Mahrattas gradually rose to supremacy both in the Deccan and Hindustan. Sivajee was born in 1627, and died in 1680. After Arungzebe's death, in 1707, the Mogul Empire fell into rapid decay, and the Punjab, Rajpootana, Oude, Bengal, Bahar, Orissa, Rohilcund, the Carnatic, and the Nizam-ul-Mulk had already become virtually independent, when the whirlwind of Nadir Shah's invasion in 1739 swept over India. It was then that Baji Rao, the second Mahratta Peishwa, assembled the whole powers of the Deccan, and marched at their head to the relief of Delhi. Nadir Shah retreated as Baji Rao advanced, but in his army was Ahmed Shah Abdali (Durani), destined to overthrow the supremacy of the Mahrattas for ever on the memorable plain of Panipat, in 1759. Such was the political condition of India in the reign of the 12th Mogol, Mohammed Shah (1719-1748), on the eve of the English conquest.

The French had bought Pondicherry in 1672-74, Chandernagore in 1688, and Yanon in 1706, and Mahe was taken by them in 1725, and Carical ceded by the Rajah of Tanjore in 1739; and in 1741 Dupleix became Governor-General of the French possessions in India. In 1740 the Mahrattas, having invaded the Carnatic, and the French having given refuge to the Nawab's son, received the thanks of the Nizam. Duplex now resolved to expel the English from India, and tho opportunity was afforded him in the war between England and France in 1740-48. Madras was surrendered to the French in 1746, and the English might now have really lost India but for the conclusion of the Peace of Aix-la-Chapelle, and the concurrent deaths of the Great Mogul (Mohammed Shah), and the Peishwa (Sahu), and the Nizan-ul-Mulk, all in the same year, 1748.

The death of the Nizam-al-Mulk was followed by a disputed succession, in which the English and French took opposite sides, with the result that in 1751 Salabut Jung, the younger son of the Nizam-al-Mulk, was installed at Aurungabad as Subadhar of the Deccan by Bussy, and the whole of Southern India was virtually placed under French domination.

The English having, however, under Clive, recovered their position in the Carnatic, the French, in 1757, sent out Lally, expressly to expel them from India. Clive had been meanwhile called away to Bengal to avenge the massacre of the "Black Hole" on the plains of Plassy; but in the course of the year Sir Eyre Coote arrived from England, and in December, 1759, utterly and for ever annihilated the French power in India on the field of Wandewash.

Mir Jaffir, whom we set up after Plassy, as Nawab of Bengal, and from whom we obtained "the Zemindary of the 24 Pergunnahs," was deposed by us in 1760, in favour of his son, Mir Cassim, but owing to some disagreements with Mir Cassim; we reinstated Mir Jaffir as Nawab Nazim. This led to the massacre of Patna in 1763, avenged by the battle of Buxar in 1764, and the annexation of Bengal, Bahar, and Orissa to the Company's dominion. Hindustan was swept clear of its Afghan pests during the Rohilla war of 1775.

From the fall of Bijanagar in 1565 a Hindu dynasty reigned in Mysore until 1761, when Hyder Ali, an officer in the reigning Rajah's army, usurped his sovereign's throne. This led to the four Mysore wars in 1767-9; in 1780-4, when Hyder Ali was defeated by Sir Eyre Coote on the very field of Wandewash, where, 22 years before, he had gained his decisive victory over the French; in 1790-2, when half of Tippoo Sahib's dominions were divided between the English and their allies;

and in 1798-99, when we stormed Seringapatam, and restored Mysore to the dynasty of its ancient Hindu rulers.

It remained only to release India from the Mahrattas, whom it also took four wars to finally reduce; namely, those of 1780-82, 1803, 1804-5, and 1817-19. There was no power left now in India to oppose or disturb our supremacy, and the Afghan wars of 1839-44, although marked by untoward circumstances and one great disaster, for ever freed India from all fear of foreign invasion. Scinde was annexed in 1843, the Punjab in 1849, Pegu in 1852, and Oude in 1856. The subjugation of India was complete. The work of consolidation began with the famous reforms of Lord William Bentinck in 1828, and was but confirmed, through the over-ruling providence of God, by the terrible mutiny of the Bengal army in 1857, the date of the real beginning of the history of British India as an autonomous empire, to which the preceding century of conquest, from 1757, and the antecedent century of merely trading relations, in the factory period, from 1600 to 1708-9, were but the prelude. The Queen of the United Kingdom was proclaimed Empress of India—*Kaisar-i-Hind*—January 1st, 1877.

Inventory of the Company's Conquests.

December 26, 1757,—"The 24 Pergunnahs," from the Nawab of Bengal.

May 14, 1759.—Masulipatam, from the Nizam.

September 27, 1760.—Burdwan, Midnapore, and Chittagong, from the Nawab of Bengal.

August 12, 1765.—Bengal and Bahar, and Orissa, from the Mogol.

August 30, 1765.—"The Company's Jaghire" in the vicinity of Madras, from the Nawab of the Carnatic.

November 12, 1766.—The "Northern Circars," from the Nizam.

May 21, 1775.—"The Zemindary of Benares," from the Vizier of Oude.

May 22, 1776.—The island of Salsette, from the Mahrattas.

June 17, 1778.—Nagore, from the Rajah of Tanjore.

September 19, 1778.—The Guntoor Circar, from the Nizam.

1786.—Pulo Penang, from the King of Queda.

March 17, 1792.—Malabar, Dindigul, Salem, &c., from Tippoo Sahib.

In 1796 Ceylon taken from the Dutch.

July 13, 1799.—Coimbatore, Canara, Wynaad, the Nilghiri Hills, &c., from Tippoo Sahib.

October 25, 1799.—Tanjore, from the Rajah of Tanjore.

October 12, 1800.—"The Ceded Districts," from the Nizam.

July 31, 1801.—The Carnatic, from the Nawab of the Carnatic.

November 10, 1801.—Goruckpoor, the Lower Dooab, Bareilly, &c., from the Vizier of Oude.

December 31, 1802.—Districts in Bundelcund, from the Mahratta Peishwa.

December 17, 1803.—Cuttack and Balasore, from the Rajah of Berar.

December 30, 1803.—Upper Doab, Delhi territory, from Scindia.

April 21, 1805.—Districts in Guzerat, from the Guicowar.

December 2, 1815.—Kumaon and part of Tarai, from Nepal.

June 13, 1817.—Saugur, Huttah, Dharwar, &c., from the Mahratta Peishwa.

November 6, 1817.—"The Ahmedabad Farm," from the Guicowar.

January 6, 1818.—Khandeish, &c., from Holkar; Ajmere, from Scindia; Poona, the Northern Concans, the Southern Mahratta country, from the Mahratta Peishwa; districts of the Nerbudda, Sumbulpoer, Patna, &c.. from the Rajah of Berar.

December 17, 1820.—Southern Concan, from the Rajah of Sawuntwarree.

August 2, 1822.—Singapore from the Rajah of Johore.

December 12, 1822.—Beejapoor and Ahmednagger, from the Nizam.

August 9, 1825.—Malacca, from the Dutch.

February 24, 1826.—Assam, Arracan, Tavoy, Tennasserim, from King of Ava.

1832.—Cachar

1834.—Coorg, from the Rajah of Coorg.

1841.—The Duars of Bhootan, from the Rajah of Bhootan.

1843.—Scinde.

1845.—The Jullunder Doob.

1849.—The Punjab and Sattara.

1852.—Pegu.

1853.—The remainder of Cachar and Berar.

1853-54.—Nagpur.

1856.—Oude and Tanjore.

Ceylon was taken from the Dutch 1795, and the whole island occupied 1815.

Conclusion.

Such is the last result of that rivalry for the trade of India and the East, which began between Jerusalem, Edom, and Tyre, and Assyria, Persia, Phœnicia, and Egypt, and, after the disruption of the Roman Empire, passed in succession from Genoa and Venice to Spain and Portugal, England and Holland. Ancient history is very much the history of the struggle for the transit trade of the East by the Persian Gulf and Red Sea; and the modern history of the Old World is almost altogether based on the opening up of the ocean-way to India round the Cape of Good Hope. The whole current of the commercial and political, social and religious history of Europe was changed by Da Gama's discovery. Venice was deprived of her mercantile supremacy, Italy lost the prosperity which had again returned to her, and Egypt, which for 2,000 years had commanded the most advantageous of all the overland roads to the East, was suddenly deposed from her position of pre-eminent superiority. The commercial monopoly of the Arabs in the Eastern seas, and of the Jews in the Mediterranean countries, was destroyed at a blow, and that re-arrangement of the mercantile and state systems of Europe was commenced which has subsisted to the present day. We have seen in our own time, since the opening of the Suez Canal and the return of much of the trade of the East to its ancient route through Egypt, how greatly the social and political condition and international relations of many of the European States have already been modified. It has, indeed, been often said during the last two or three years that Englishmen have become divided as to the policy of this country on the so-called

Eastern Question. But our apparent differences of opinion are founded simply on a fundamental change of circumstances which have not yet been generally appreciated. While all our Eastern commerce went by the Cape of Good Hope we had little more concern in the affairs of Europe than of America, but no sooner was a practicable canal pierced through the Isthmus of Suez, than it at once began to influence the course of our vast carrying trade, and our international relations with the countries lying along the new route opened to it. We may, therefore, the more readily understand the radical character of the revolution wrought, not only in the commerce and politics of Europe, but in its whole moral and intellectual life, by Da Gama's discovery. Taken with the discovery of America by Columbus, it profoundly agitated the hearts and minds of the people of Europe. The multitude were stirred by an uncontrollable lust of riches and spirit of adventure; and the cultivated by the sense of a renewed faith and hope, at the moment when Christendom was almost sinking into the old despair of human destiny and duty which marked the decline of Imperial Rome. For all men the sphere of human duty and sympathy was permanently and indefinitely enlarged. The discovery of the Indies was, for Europe, nothing less than the discovery of a new moral world and the definitive emancipation of the human soul from the spiritual trammels in which it had been all through the dark ages. Its quickening effect on the genius of Europe was at once made manifest. Camoens, the author of the first epic of modern times, was directly inspired by the discovery of India by his countrymen. He was rapidly followed by Tasso, Cervantes, Spencer, Shakespeare, Milton, Raphael, Michael Angelo, Titian, Luther, and Francis Bacon; and the wide moral gulf which separates the genius of these men from the certainly not lesser genius of Roger Bacon, Aquinas, Giotto, and Fra Angelico, Chaucer, Gower, Rabelais, and Dante, is the measure of the spiritual freedom that was conquered for mankind by the discoveries of Columbus, Da Gama, and Magellan. The impression made by them on the English people was immediate and abiding. It may be traced everywhere in the writers of the reign of Queen Elizabeth, particularly in Shakespeare and Ben Jonson, and in the elevation of character of all the historical men and women of the age. Even in their infamies, they were superhuman. Da Gama's discovery, in fact, changed the face of Europe from the Mediterranean to the Atlantic, and the British Isles, which had before been wasting in the obscurity of their native fogs, were at once placed in the fore front of the new line of human advancement; and, as the geographical centre of the four continents of the globe, they became, in the course of 200 years, the common emporium of the whole sea-borne merchandise of the world. The establishment of the East India Company was the first step of the prodigious political development of England in the 17th and 18th centuries, and the foundation of all our mercantile prosperity and naval power. It was the possession of India, the command which its possession give us of the trade of the East, which enabled us to contend victoriously against the European coalition which threatened our commercial supremacy at the beginning of the present century; and it is the peaceful possession of India which is our chief stay in sustaining the maritime greatness and preponderating productive power of this country, in the crushing commercial competition of the modern world. It is not necessary that I should more than allude to the ends—the peace, well-being, and freedom of mankind—for which we chiefly prize the proud position won for us by the courage of our forefathers. There has, indeed, revived of late a fashion of decrying patriotism. But, as Ben Jonson said in his day, there is a necessity for it, as would be quickly found if once its spirit began to decay among us, and those who deride it are but beguiled by their own words, and in their hearts are as true as any other Englishman to the honour and greatness of their country,—

> "The stem of the world's desire, and the tree that shall not be abased."

DISCUSSION.

The Chairman said he thought Dr. Birdwood had done himself but scant justice in the time he had taken to read this paper, which contained a vast amount of learning and information. He had often thought that the story of India was very little known to the people of this country *en masse*, and yet what a romance it was. It read like the tale of a Troubadour, and he thought that attention could not be too soon generally directed to it. He could only say for himself that he found it a mine of amusement and information whenever he took it up, and he trusted when this paper appeared in the *Jouenal* it would attract more attention to the subject than it had hitherto received.

Colonel Yule, C.B., said he thought that when this paper was published, the public would cease to complain of the dulness of the history of India. The field Dr. Birdwood had taken for observation was a very large one, but one or two points struck him, which he might mention. One was the extreme antiquity of the Indian trade. As regards the trade with the Mediterranean they could not go continuously very far back; but there was the strongest reason to believe that voyages in the reign of Solomon were made to the western coast of India. After that they found many but scanty and unsatisfactory notices of trade along the Indian coast in Greek and Roman times. Some of these were contained in Ptolemy's geography, and they learned from him that traders from the Mediterranean did pass, not only all round the coast of the Indian peninsula, but to further India, and, if not to China, at least to ports under the influence of China. They learned also, even from the meagre list of names, of which his geography too much consisted, that along the whole coast of what was now called British Burmah, but was then far from being British, its names of towns and ports were undoubtedly Indian. They were Sanscrit names, and they extended almost all the way to China. That showed that when Ptolemy wrote in the second century, and probably most of his information was at least a century older than himself, Indian traders and emigrants had passed from the Sanscrit speaking countries of India into the further peninsula, and probably to China. For instance, Ptolemy mentioned the island of Java, under the name of Java-Diu, and explained that the word meant an island of barley, and Java, in the Indian language, meant barley or grain. They had only very fragmentary notices of this trade with the East, but, by putting this and that together, it was evident that it had never been suspended. In another geographical work, which was supposed to belong to the first century, commonly called the "Periplus of the Erythrean Sea," the coast of

India was described, the whole coast of western Asia; in fact, he followed the peninsula of India down the western coast and up the eastern to the Ganges, but beyond that his information was indefinite. He described the sailing up what was now called the Coromandel coast to a district which was undoubtedly that of the mouth of the Godavery, where the great irrigation works were now constructed. From that point he said vessels struck across the bay until they reached a certain point called Alura, which was the point of departure for them in going to Crysi, which evidently referred to a portion of Burmah now bearing a name meaning the golden land, and to this day one of the titles of the King of Burmah had a similar meaning. They did not venture to strike across to Sumatra and so to China. The next notice they got was that which Dr. Birdwood alluded to, the book of Cosmas, a very curious Greek work of the 16th century. This Cosmas had been originally a merchant trafficking to the East, but in his old days he became a monk, and wrote a very long tedious book which was to demonstrate the true scriptural theory of the earth. According to him the earth was not round, but oblong and flat, and the heavens were erected over it. He gave a very remarkable drawing, in which you saw the form of the universe as he conceived it, exactly like a large lady's trunk of rectangular form, with a great vaulted roof. However, in his tedious discussion of this subject, he dropped here and there what he probably supposed to be the least valuable part of his work—a great many notes of his own travels to the coast of India, which were exceedingly interesting. He mentioned the ports of Malabar, which were then traded to for pepper; Ceylon, about which he gave some curious anecdotes, saying that Christians were found both in Ceylon and on the coast of western India, and he was the first who distinctly mentioned the trade of China. He knew China by the name of Chinastan, which was very nearly the same word by which it would be known in Persia to this day. He said that beyond India you passed to the country from which cloves came, and, therefore, he must have had some dim idea of the Malaccas and the Indian Archipelago. From there he said you turned far to the left and arrived at the land of Chinastan. These little bits of intelligence were merely like lamps here and there in a great space of darkness, and for centuries we found no further information on the subject. The next book of any importance was the Arab work which Dr. Birdwood referred to, which translation was published by Abbe Renaudot. That described the trade of the Arabs from the Persian Gulf to China, in the seventh, eighth, and ninth centuries. At that time they no longer hugged the shore of India as they had done in the times of the Greeks, but struck across from Ceylon to Sumatra. They mentioned Ceylon, the Andaman Islands, and the ferocious savages who inhabited them; they also mentioned the Nicobar Islands under another name, but there could be no mistake as to their identity. They described Sumatra under various names, mentioning the camphor found there, which was considered immensely valuable. Then they touched at some port on the peninsula of Malacca, and struck across to Chamfu, which was the lower part of the Eastern Peninsula, near which the French settlements now were, and from thence went on to China, though it was not quite certain to what port there they traded, but probably it was Hang-Chow. From that time a period of darkness again set in. There was no doubt the trade continued, although with interruptions and revivals, and when we came to the time of Marco Polo and others in the 13th century, we again had an immense trade received between India and China. Chinese junks with immense burthens came every year from Fokien to Malabar, coming with one monsoon and returning with another. Of course, before the discovery of the Cape, no European vessels were found in those seas, but in the course of the 14th century a remarkable land trade sprung up with China from Europe. Merchants of Genoa carried on a regular trade by the Black Sea, starting from Azof and going up to the Volga, and going across the whole longitude of Asia until they arrived in China. They generally carried gold and silver for the purchase of silks, velvets, and satins, which they brought back from thence. This did not last very long, perhaps 20 or 30 years, but it was long enough for the Genoese to establish factories in several ports in China, and probably also in Pekin. And at the same time missionaries and Roman bishops established themselves in China. All that came to an end with the fall of the Mongol dynasty, which then reigned in China. The Chinese native dynasty overthrew it about 1368, and from that time the trade languished and ceased. But at the same time the Mongols, who had kept Asia open, had fallen, or had become converted to Mahommedanism, with the usual consequences in those days, that it excluded all strangers and travellers from the country. We often heard that China was discovered by the Portuguese about 1516 or 1517, but the fact was it was re-discovered, for it had been, under the name of Cathay, well known at least to the merchants of Italy, several centuries before.

Sir Joseph Fayrer, M.D., K.C.S.I. said perhaps Dr. Birdwood could give them some further information about the point mentioned by the last speaker, namely, the voyages of Solomon, and he should be glad if he could tell them where those ships which used to be broken at Eziongeber went to—whether it was to Ceylon or to the west coast of India. He never could satisfy himself on that point. The paper, of course, was historical, and, therefore, did not deal with geography; but he could not help thinking that, when he described the importance of those great discoveries which he traced so far back, something might be said as to the magnitude of that country. When speaking of that coast-line and those ports, he wondered to himself if it ever occurred to those who listened that that coast-line extended about 4,500 miles; that India, which occupied such a small portion of the southern part of Asia, was nearly as large as the whole of Europe, excluding Russia; and that the population was equal to the population of Europe, excluding Russia.

Dr. Birdwood said Solomon's voyages occurred before the period dealt with in his paper, and he had omitted all reference to them because he had already gone over that ground in his "Introduction to the Indian Court." As to where Solomon's ships went to, Colonel Yule had already intimated that it was supposed that they went to the western coast of India, and some man who came to Bombay made sure they did, because he had found gold at Mysore, where it was said to have been found. However, he did not think that Jews would have left any gold in any country they ever went to. He could not say whether they went to Ceylon, and it was very difficult for anyone to say certainly. His impression was that Solomon's ships did not get beyond Aden, and there met the produce of India, because it would take three years to go down from Eziongeber to Aden and back. It was a coasting trade in those days; they would have to wait for winds, and to exchange merchandise.

Sir Rutherford Alcock, K.C.B., said there was no doubt that in the 9th century the Arabs were great traders, not only in the Eastern Archipelago, but thence still farther to the east, for distinct traces of them were found in Cochin. There was one peculiarity which had often struck him, having been stationed in that province, that all the boatmen wore turbans to this day, and they were the only Chinese who did. He could not help thinking sometimes, in seeing a somewhat handsome physiognomy, beauty not being a distinguishing mark of the Mongols and Chinese, that he traced home the fine Arab features in them. They had not only good noses, but tolerably straight eyes, and altogether were a great improvement

on their neighbours. They prevailed in considerable numbers; and this wearing of turbans was one of the most striking evidences of a custom like that coming down for many centuries. In the 9th century, ages before the passage round the Cape was discovered, it was the common track for Arabs who crossed over from Ceylon to trade on the Indian coast. No doubt they also had a trade with Burmah, but these seemed to have very considerable operations going on with the coast of China. He could not altogether agree with one remark of Colonel Yule's, as to the effect of the conversion of the Mongols to Mohammedanism. He really did not think change of religion had much influence in the matter, because the Chinese dynasty which succeeded was still more exclusive, and they were all Buddhists. There was nothing more marvellous in history, and this no one had done more to illustrate and make interesting than Colonel Yule in his edition of "Marco Polo," than to see the enthusiasm, energy, and courage with which the Venetian and Italian merchants travelled from the Black Sea to the extreme borders of China, taking two or three years for the journey. He doubted very much whether the merchants of the present day were at all prepared to undergo such frightful risks and hardships.

The Chairman—What merchandise would bear the cost of such a journey?

Sir Rutherford Alcock said no doubt these old merchants dealt in very costly merchandise, and it would not pay now-a-days. Still we owed very much to them for the knowledge they gave us of this great empire, and we also owed very much to China and to the Chinese. Whatever might be thought about printing, the compass, and gunpowder, we certainly got some of our greatest luxuries from China, such as tea, silk, porcelain, and lacquer. Lin, one of the greatest opponents of opium trade, used to say, "What would you have done, you wretched barbarians, without our tea and without our rhubarb." Although they were far behind us now, there was no doubt they possessed a high amount of culture when the English must have been painted savages.

Mr. Dipnall said Dr. Birdwood seemed to have omitted any treatment of the great ethnographical facts connected with India, the origin of these great populations without which there could have been no trade. And also how it was that these great caravans could have been supported in their long journeys of two or three years' duration, which they could hardly have been unless they met with large populations and towns on their route. Perhaps on some future occasion this would form an interesting subject for a paper.

The Chairman then closed the discussion by proposing a vote of thanks to Dr. Birdwood for his extremely interesting paper. It was strange to hear these tales of adventurous merchants in former days undertaking such hardships as they seemed to have passed through, but in those days people had a strange idea of India. It was looked upon as a kind of Aladdin's garden, where pearls and diamonds hung on the trees; in fact, at the beginning of this century, persons looked upon it as a perfect mine of wealth. Now we were told to consider it as a very poor country, and he was afraid that was the more correct view.

NINTH ORDINARY MEETING.

Wednesday, February 5th, 1879; Sir Charles E. Trevelyan, Bart., in the chair.

The following candidates were proposed for election as members of the Society:—

Binns, Edmund Knowles, Fig-tree-chambers, Sheffield, and 216, Heavygate-road, Sheffield.
Donovan, H. C., 17, Bonfield-road, Lewisham, S.E.
Harward, Gainsborough, Stourbridge, Worcestershire.
Mathieson, James, India-rubber, Gutta-percha, and Telegraph Works Company, Silvertown, Essex.
Neill, George Dempster, Greenock.
Ross, Thomas, 70, Hampstead-road, N.W.
Smith, Henry, J.P., Summer-hill, Kinswinford, and Brierley-hill Iron Works, Brierley-hill, Staffordshire.
Straube, Albert, 63, South-hill-park, Hampstead, N.W.
Stroh, Augustus, 42a, Hampstead-road, N.W.
Wall, Thomas Leetham, Leyland, near Preston, Lancashire.

The following candidates were balloted for and duly elected members of the Society:—

Bloor, John Uzielli, 20, Highbury-place, N.
Burt, George, 19, Grosvenor-road, S.W.

The paper read was—

THE BEST METHODS FOR IMPROVING THE CONDITION OF THE BLIND.

By T. R. Armitage, M.D.

Nine years ago, I had the honour of addressing an audience within these walls on the same subject as that under our consideration to-night, and, curiously enough, Sir Charles Trevelyan was in the chair on that occasion as on the present. Things have changed so much since that time that it is well briefly to record progress; but there is also another reason for my standing before you to-night. Though the principles on which the education and employment of the blind should rest are thoroughly well understood by the initiated, and although the subject has been brought more under public notice during the last 10 years than at any previous period; still, there is much misconception on some of the most fundamental and best ascertained points. According to the last census returns, there were 31,159 blind persons in the United Kingdom, or 1 in 1,015 of the population. The proportions in different parts of the kingdom vary greatly, from 1 in 635 in Cornwall to 1 in 1,367 in Durham, the proportion being higher in agricultural than in urban districts. It is a matter of congratulation to know that, in successive census returns, though the actual number of the blind increases, their proportion to the seeing population diminishes—a change which is probably due, partly, to the improvements in opthalmic surgery, partly to the greater attention paid to the laws of hygiene. But there are some dark statistics to check our self-complacency. According to a paper read by M. Marjolin before the Paris Congress last autumn, out of 208 pupils then in the Paris Institution, 80 became blind from purulent opthalmia, and 18 from small-pox; so that nearly one-half lost their sight from preventable causes. In the institutions of Germany the loss of sight from purulent ophthalmia is stated to be about 30 per cent. I have not been able to procure reliable statistics from any British institution, except York. I learn from Mr. Buckle, the manager of the York School, that out of 82 pupils at present in the school, 36 lost their sight from this cause; for although all these cases were not certified by the

surgeon as purulent ophthalmia, they probably were all due to it.

Purulent ophthalmia is highly contagious, but when occurring in children can generally be cured by remedial measures and strict attention to cleanliness; as, however, the delay of a few hours may make the case hopeless, a surgeon should be sent for at once. This information should be circulated as widely as possible among midwives, monthly nurses, &c. Blindness from small-pox is due from neglect of proper vaccination, and its occurrence is a disgrace to a civilised country. Among the most frequent causes of blindness in adult life is a wasting of the optic nerve, which, in many cases, is due to excessive smoking, and is, therefore, also often preventable. If the blindness, originating from these three causes, could be eliminated, the census returns would soon show a more favourable result.

The problem, how best to raise the social condition of the blind may be divided into two principal heads—The best means of educating them, and the best way of employing them. There is a prevalent idea that the blind are always cheerful. This is certainly not usually the case with the uneducated and neglected. I am intimately acquainted with some of the founders of the Indigent Blind Visiting Society, which during the past forty years has done so much to raise the condition of the blind of London. Their description of the state of degradation at that time is horrible. Even now blind children are sometimes discovered shut up in cellars, cowering over the fire, afraid to move, and apparently almost idiotic. When such children are taken to school, months sometimes elapse before it can be decided whether they are idiotic or not; and, without great patience and judicious training, they grow up to be professional beggars or to be a burden on the parish. In considering the education of the blind, my time will not allow me to go into questions of hygiene or general management, important as those subjects are, but it will be more desirable to confine myself rather to the apparatus used in teaching, because it is in this that the greatest improvement has taken place, and it is mainly due to this improvement that the great advance in their education which has taken place during the last few years has become possible. Embossed printing was introduced by Valentin Haüy in 1784. He naturally used the Roman letter for this purpose, and adopted the italic form, as being, in his opinion, the most legible. Gall, of Edinburgh, soon afterwards printed books in which he made the Roman letter take an angular form with serrated lines. Alston, of Glasgow, then printed in Roman capitals. Dr. Howe, of Boston, United States, employed another modification. The Bible has been printed at Stuttgard in Roman capitals with serrated lines; in Vienna in capitals and small letters, as also at Worcester. These are only a few of the modifications of the Roman letter that have been extensively used. Its general prevalence illustrates the difficulty which the seeing have in escaping from the groove to which they are accustomed; while the numerous modifications arise from the vain endeavour to make that tangible which from its very structure is difficult to be felt. Examples are on the table of most of the modifications which I have mentioned. I doubt whether any seeing person in the room can read three consecutive letters by the finger if the eyes are kept shut; and, though many blind can be trained to read the Roman letter, many cannot; and most who are able to read it will not do so from choice if they have learnt one of the simpler forms.

The two shorthand systems of Frere and Lucas are comparatively little used now; they possess many of the advantages of shorthand systems, and allow of rapid and therefore pleasant reading, but they lead to bad spelling, and are, therefore, not to be recommended for the education of the young.

Moon's system is more used than any other in the United Kingdom. The letters are formed of a simple combination of lines, and are very easily felt. On this account it is most useful to those who have lost their delicacy of touch by manual labour.

All the forms of letters hitherto mentioned consist of lines. There are others which consist of raised dots, the most important of which is that introduced by M. Louis Braille, in 1834, a blind pupil, and afterwards teacher of the Paris Blind Institution. It consists of various combinations of six dots. The construction of the alphabet is so simple, that I have often known intelligent pupils learn it in half an hour, and it is extremely legible by the finger, but its great advantage is the facility with which it can be written, thus enabling the blind to write from dictation, to write themes, and to be educated very much in the same way as seeing children; while, for those who are older, the power of taking notes of books, of lectures, &c., the possibility of writing letters, keeping accounts, journals, and the hundred other applications of writing, make the acquisition of this system of the greatest possible value. In addition to these many advantages, the Braille system is capable of being applied for musical notation, and a large and varied library of music has been published at Paris and Copenhagen. An excellent collection of organ music has been published at Lausanne, and several valuable small school works by the British and Foreign Blind Association of London. The blind can write their own music by means of a simple and inexpensive writing frame, which is the same as that used for ordinary writing. This writing frame consists of two pieces of brass hinged together, the lower of which contains a succession of groups, each consisting of six pits. The other piece, called the guide, is pierced with a series of oblong holes, and when the two are locked together, each hole in the guide exactly corresponds to a group of six pits in the bed. In writing, the paper is placed between the bed and guide, and a steel point, directed by openings in the guide, carries little prominences of paper into the pits, which by their varying combinations can be made to represent all the letters of the alphabet, the signs of arithmetic, and every form of note and expression used in music.

Though this admirable system was introduced into Paris so long ago as 1834, it was some time before it became generally adopted, even there; though, from the fact of nearly all the teachers being blind, opposition has long since been overcome, and no other system is now used in France. In England, although a few isolated blind knew and used the

system many years ago, its general introduction is due to its adoption by the British and Foreign Blind Association, which was founded in 1868, in order to investigate the methods of educating and employing the blind, practised in this and other countries, and to bring into general use those methods which the experience of those best qualified to judge should decide to be the best.

The first step was the selection of the executive council; it was felt that the education of the blind had suffered so much from the prejudices of seeing philanthropists who had taken the subject up, that it was decided that no one should be qualified to sit on the executive council whose possession of eyesight might bias his conclusions derived from touch. The results have abundantly justified the wisdom of this decision. England, ten years ago, was one of the most backward of civilised countries in all that concerns the higher education of the blind. She is now unrivalled in the production of educational apparatus for their use; and the improvements in writing and printing introduced here are spreading to all parts of Europe and to the most distant parts of the world. A few months ago the Association was applied to by the Japanese Government for a complete set of maps, books, and other educational apparatus. No doubt the intention is to copy them in Japan, and very likely to improve upon them.

A Congress for the improvement of the condition of the blind was held in Paris last autumn, attended by representatives from all parts of Europe. The decisions come to were almost identical with those arrived at long ago by the Association. In particular, the decision that the Braille system was worthy of universal adoption, was carried by an overwhelming majority. It has been stated in one or two English papers that the representatives of England, as a body, dissented from this view, and I have had letters from foreign members of the Congress expressing surprise at such a statement. To the honour of England, be it spoken, such was not the case, though there were certainly three Englishmen and two Frenchmen in the minority, and, I think, no more. I am acquainted with all of these gentlemen, and believe that not one can read or write by the Braille system. All, with one exception, are absolutely and entirely ignorant of it; and though they agreed in opposing the decision of the majority (consisting of about 150), they did not agree as to to what they would substitute for it, but had no less than three opposition schemes. In the endless discussions that have taken place respecting embossed type, two parties stand in almost constant antagonism—the blind on the one side and the seeing on the other.

It may be of use briefly to consider the reasons which are given by those few seeing teachers who are still staunch adherents of the Roman letter. The principal argument is that the blind are isolated by using any letter differing from that in ordinary use by the seeing. But the blind maintain, on the contrary, that they are isolated by being compelled to use methods of work not well adapted to the sense of touch, and that this isolation is diminished by everything which enables them to work with rapidity and accuracy, and that blind children are entitled to be taught to read, write, cipher, &c., by the most approved methods, even if the seeing teacher has to devote an hour or two to learn the method specially adapted to touch; in fact, that the seeing teacher exists for the benefit of his blind pupils, and if he does not choose to learn the best methods, it is easy, as in Paris, to have blind teachers and seeing superintendents.

But there is another reason which, though not often expressed, is really often at the bottom of the opposition to the Braille system in schools, viz., the fear of the abuse by the pupils of the power of letter writing; but, surely, exactly the same objection exists in schools for the seeing, and yet no sensible man will on this account wish that writing should be discontinued altogether. The remedy is for the seeing superintendents to learn Braille, which they can do as well as the parents and relatives of the blind, who find no difficulty in learning it in order to correspond with them. If a blind man were to presume to set right the mistaken ideas of the seeing with regard to the colour of a landscape or picture, every one would laugh at him for his conceit; and the case is much the same when the seeing oppose the opinions of the blind with regard to touch. I am, however, happy to say that I know some seeing teachers who are as enlightened on questions of touch as the blind themselves, and that I have seen so many abandon their old prejudices, that I am not without hope that the time will come, when no seeing teacher will throw unnecessary difficulties in the way of the pupils entrusted to his care. I wish it to be distinctly understood that I do not wish to banish the use of the Roman letter entirely from blind schools, but to point out its great inferiority as a means of education. I think all blind children should be taught the form of the letter used by the seeing, just as they should learn the forms of any objects of common occurrence. Besides, some valuable books have been printed in America in the Roman letter, and there are undoubtedly some blind who possess sufficient delicacy of touch to read them. I have also omitted to mention the system of point writing now used in most United States institutions, and known as the New York system. I think it is unfortunate that the Americans have separated themselves from the rest of the civilised world; but the New York system, like the Braille, can be readily written, and therefore the blind have, by its use, the advantages that the blind of other countries have from the use of Braille. Specimens of the best form of relief maps and calculating machines are on the table, but my time will not allow me to go into their description.

I now come to the second part of my subject, viz., the best means of employing the blind. No doubt, the profession of music furnishes the most remunerative employment, whether they become teachers of music, organists, or tuners. At my last address here, nine years ago, I insisted strongly on this point, and a few days afterwards met with a blind gentleman who seemed to be eminently qualified to take the direction of a great school of music. The result was the formation of "The Royal Normal College and Academy of Music for the Blind," at Upper Norwood, which is probably the best school of its sort in the world. The number of pupils at the Paris Blind School, who become entirely self-supporting by the profession of music,

is about 30 per cent. The proportion in the Royal Normal College ought to be, and is, very much higher, as the pupils are more carefully selected. It has not been in operation long enough to make it possible to speak with certainty, but I do not think that I over estimate its success when I state that from 70 to 80 per cent. of the pupils who pass through its curriculum are able to make incomes varying from £50 to £150 a year, and as good blind musicians and tuners become more numerous, the prejudice now existing against their employment will undoubtedly diminish, as it has done in Paris. But many blind persons cannot become sufficiently good musicians to earn their living by it, and manual labour will always have to be followed by many. The trades most usually practised by the blind are basket-making, chair-caning, brush-making, mat weaving, rope-making, turning, and mattress-making. In many of our large towns all the blind who are capable of work are constantly employed. At the Royal Blind Asylum, Edinburgh, 185 blind are employed, and the sales in 1877 amounted to £20,000; and though this amount did not all arise from work done by the blind, yet as £5,522 was earned by them as wages, their position in the northern capital may be considered satisfactory. The Liverpool workshops employ 115 blind; their sales for 1877 amounted to £12,255, and the wages to £3,900. In other towns, such as Glasgow, Bradford, Leicester, Sheffield, &c., the results are equally satisfactory. In London, with a blind population of about 3,000, only 127 are employed at workshops. The total sales for 1877 amounted to £8,516, the united wages to about £3,500. It is true that this does not represent the entire earnings of the blind of London, as some are employed as missionaries, others to circulate books, others keep small shops or sell newspapers and other things, while some earn their living as teachers of music, organists, and tuners. Many women earn a little by fancy wool work and by sack-making, and there are a few more unusual trades practised, such as loading and unloading carts, buying and selling horses, &c. But when all these have been taken into consideration, there remain a great number of unemployed blind capable of and anxious for work. It is very sad to be applied to repeatedly by the blind or their friends in such cases as these. A man becomes blind and is incapacitated from following his former employment. He is perhaps the bread-winner of the family, and all that he wants is to be put in the way of earning his living by honest toil. In many such cases the answer must be that, as things are now, it will be difficult for him to do more than earn a small pittance by turning a mangle or some such occupation, and one regrets that his lot has not been cast in some provincial town where there is more enlightenment and better management. We in London have not attempted the best kind of handicraft, which is undoubtedly the making of bedding, mattresses, palliasses, feather beds, &c. In Edinburgh about 60 blind people find work in this way, and the Blind Asylum there has such a reputation for its bedding, that it has always as many orders as it can execute. Why should not London attempt something similar? I am certain that a large bedding establishment might be started with success, where ladies could obtain bedsteads and bedding of all sorts, but differing from other similar establishments by most of the work being done by the blind. I pointed out in my last address that pianoforte tuning was an occupation which they could follow with great success and profit. This idea has since been successfuly carried out. I am no less certain that in mattress making we have another most valuable trade, and I hope that it will soon be fully and fairly tried.

DISCUSSION.

The Chairman said—All will agree that Dr. Armitage had established a fresh claim upon the public gratitude, for he had advanced this most important matter another step. I shall briefly allude only to two points in his interesting and important lecture. First, as to the allusions to these causes of blindness which are preventable, such as purulent opthalmia, small-pox, and excessive smoking. In one sense it is very lamentable that so much blindness should be caused in such a manner, but in another sense it is highly satisfactory, because although what is passed is irremediable, the future is in our own hands, and I would strongly submit to Dr. Armitage that it is of great importance that this point should be brought in some prominent manner before the medical profession and officers of health. The greater part of Dr. Armitage's paper related to the much vexed question of the best printed characters for the blind. Now, this really involves two entirely different points. First, which is the best type absolutely, and next the importance of having only one type, whether it is the best or not. About the importance of having only one type there can be no doubt whatever, and the advantages of a general uniform type must outweigh any small balance of advantage between the different types. I do not mean to say but that, among all the types proposed, there may be one or two, or perhaps more, which are so bad that their general adoption would be a great evil, but, nevertheless, where opinion is so much divided between different types, the presumption is that the difference between them is not very great. Now, that we should only have one type is a matter of the utmost importance, because without it the blind can have no common literature—nor any sufficient literature. The literature of the blind is at present confined to the Bible and a few elementary books, because people will not venture to provide literature of this character, incurring great labour and expense, in turning out standard works in type for the blind, from the fear that all their labour may be in vain. Dr. Armitage remarked that the reason why the Roman type was so popular was because all sighted people naturally favoured it. No doubt that is a very great cause, but there are other reasons also. Only about one blind person in twelve is born blind, and though, no doubt, many children become blind so young that they have not learned to read, a great many had, and in England they all learned to read in the Roman type. In my limited experience I have known several instances of persons who have learned to read while they enjoyed the blessing of sight, and who can now, without any difficulty at all, read in the Roman type. The other day, I saw a relative of my own reading the Psalms in the Roman characters; and another lady, with whom I am acquainted, not only reads and writes easily, but has published a book of poetry. Again, the majority of teachers understand only the Roman type, and it is difficult to get them to learn any other. If the blind are in the main to be educated with the sighted, it is very important that they should learn the same characters. Now, it is of extreme importance that they should be taught with sighted

children; but though they have lost one sense, they still have their hearing, and, if they can take an active part in the school class, they will learn a great deal through their ears. Again, there is the family and home to be taken into account, and any system not based upon home instruction and association must be open to objection. If the blind learn the same characters as the sighted, their fathers and mothers and brothers and sisters may all help them, and they would drink in knowledge from morning to night. My attention was first called to this subject, by Dr. Armitage. nine years ago. I have since heard and discussed it a great deal, and will briefly state my own opinions on the main points of school instruction. The blind are in a fixed proportion (about one in a thousand) to the general population of all classes. The great majority, therefore, belong to the working class in town and country, who, although able to support themselves under ordinary circumstances, are easily broken down by having to support a helpless member of their family, and they are quite unable to make the expensive scientific arrangements necessary to educate such afflicted member to some degree of happiness and usefulness. And, if it is necessary to educate sighted children, and to train them in useful work, how much more so is it with a blind child, who has to be carefully taught everything which sighted children see and pick up for themselves. Under these affecting circumstances, let us see how we have fulfilled our national obligations to our blind. The whole number of blind in London is rather under 3,000, of whom 493, or one-sixth of the whole, were, in July, 1875, in the metropolitan workhouses, if buildings can properly be called workhouses in which no work is done, but the inmates vegetate in stagnant, degrading idleness. There is no return of the blind in the provincial workhouses, but, as the proportion provided for by charity is much smaller in the country than in London, the number in the provincial workhouses is likely to be larger. It is estimated that, out of the 3,000 blind in the metropolis, 900 would be able to support themselves if they were properly trained and employed; but industrial training has been provided only for about 50, and remunerative employment for about 127. Out of rather more than 30,000 blind in the United Kingdom, at least 10,000 are capable, if properly trained, of supporting themselves; but scarcely 800 are at work. Until lately, private charity alone has attempted to provide for the requirements of the blind; but the task has proved entirely beyond its power. There are obvious reasons for this result. The mere pecuniary charge is too great to be persistently maintained, by voluntary contributions, at the required level, and the educational and industrial training of the blind demand such large professional experience, and such comprehensive administrative arrangements, as are quite beyond the desultory exertions of private charity, which even in its corporate efforts seems to retain much of the individuality, or idiosyncrasy, naturally inherent in it. Of this we had abundant proof in the proceedings of the representative Committee on the Training of the Blind, convened by the Charity Organisation Society, in 1874; and Dr. Armitage, in his paper read before the Paris Congress, says, "One striking peculiarity in the blind institutions of the United Kingdom is the want of uniformity in the principles on which they are managed. This arises from the want of general control, either by the Government or by some other central authority. It often happens that the committee of management of an institution, with the best intentions, but without much special knowledge, make mistakes in their dealings with the blind which have permanent bad consequences." Happily, the London School Board has come to the rescue with its high authority, its practically inexhaustible funds, and its abundant opportunities of commanding the widest experience and the best agency of every kind. Having undertaken the responsibility of seeing that every blind child in London and its environs is properly educated, there can be no doubt that the end will be attained. The cost of the education of the blind is exceptionally high, but only the ordinary school fee will be charged. Arrangements have already been made for establishing a sufficient number of centres of special instruction, at which blind children will be prepared for the now well-recognised plan of teaching these children in the ordinary sighted schools, and a lady has been appointed inspector to see that due effect is given to the benevolent intentions of the Board in all their details. Another inestimable advantage of the intervention of the London School Board is, that it has the command of the vexed question of the type to be henceforth in use for the blind, because it can legitimately, and even necessarily carry out its determination, by actually printing the books, which would thenceforth be used throughout all its schools. What is wanted to complete the system of blind instruction for the whole country, is that the School Boards in the provincial towns should follow the example of the London School Board, and that the Guardians of the Poor in the rural districts should avail themselves of the schools in the neighbouring towns for the education of the blind children in their respective unions. Every child (including the blind) must now, by law, be educated, with necessary teachers and appliances, either in ordinary or special schools. By several Acts of Parliament Boards of Guardians are empowered to send blind children to any certified school, and to pay the cost of their education and maintenance; and benevolent persons will not be wanting to maintain "homes" in connection with the town schools, at which blind children from the neighbouring rural districts may be suitably housed and cared for. These arrangements would obviously be for the interest of the ratepayers, as well as of the blind, because, at the expense of a moderate first cost, they would be relieved from the permanent burden of the maintenance of persons for whom they are bound to provide. I confine my remarks on this occasion to the school instruction of the blind, because it is a necessary preliminary to industrial training and remunerative employment. Major Fitzroy, whom I see present, will, I am sure, bear me out in saying that the first thing is to awaken the intellects of blind children, and get rid of the stagnation necessarily consequent on their infirmity; for it is only when their minds have been properly quickened, and developed, they can to advantage be trained to industrial employment.

Mr. C. Cooke said that some years ago, when in America, he visited several institutions of the blind, including that of Dr. Howe, and collected some interesting facts. He found that the employment of the blind was very much what had been stated. In New York he found that some of the pupils played in concerts with accuracy, others wove rugs, mats, baskets, and made other articles of simple construction. At Philadelphia, the pupils made brushes, baskets, mats, shoes, &c., and had the ordinary branches of school education, using the common Roman type. At Boston, they also practised gymnastics. There he saw Laura Bridgman, who was not only blind, but deaf and dumb, and without the sense of smell, yet she could write a letter and distinguish the notes of music. He knew of several blind persons who made a living by music, and he thought it should be cultivated as much as possible.

Mr. William Botly said the paper might be divided into three principal heads. 1. The causes of blindness, and the means to be taken to prevent it where possible; 2, the amelioration of the calamity; and 3, it showed how it was the duty, and should be privilege, of all who were in a position to do so, to assist in the good work. He already subscribed to several hospitals, but, after what he had heard, he should certainly increase his subscriptions. He had visited everyone of the institutions mentioned in the paper, and had been exceedingly

pleased with what he had seen there. As he happened to live near the Normal College at Norwood, he could bear testimoney to all that had been said regarding it. A few weeks since he was present, when a concert was given by the pupils in a most admirable style. The Princess Mary, and the Dean of Westminster, were present, and he was happy to say that the Duke of Westminster, who had already given £500 towards it, had promised to continue the same subscription for two years longer.

Vice-Admiral Sir E. S. Sotheby was surprised to find there was but so small a number of blind workmen employed in London, and he thought the institution with which he was connected—the Association for the General Welfare of the Blind, 28, Berners-street—occupied rather a proud position, since it employed 95 out of the whole number. They were engaged in all the different occupations enumerated, except mattress-making, and that would have been undertaken but their landlord was in that business himself, and a clause in the lease forbade it being carried on on the premises. He was happy to say that, during the winter, they had not been obliged to discharge any of the workpeople. It appeared that, in Glasgow, the annual amount of goods sold was about £20,000, and that £5,000 was paid in wages; they sold £4,800 worth of goods, and paid £2,600, or rather over half, in wages. He was afraid they had been treated rather hardly at the meeting of the Charity Organisation Society with regard to the elections, and, for his own part, he perfectly agreed that it was a bad system; but, when talking it over with some of his lady friends, they said—Take away the votes, and we shall take away our subscriptions. They could not afford to do this, for he was sorry to say the subscriptions and donations had fallen off a great deal this year; but, in spite of that, they had been able to keep the ship afloat. They did not submit the people to a second election, but when once admitted, they were kept on as long as they did their work properly. Employment was everything for the blind; if left to themselves they moped at home in their miserable hovels, almost losing their senses from doing nothing; but employ them, and they were as happy as other people. They were allowed to make as much noise as they liked in the workshops, and they were constantly singing. The great feature in all these institutions was taking the pupils early; for after they passed 35 or 40 their fingers got so stiff that it was almost impossible to teach them any mechanical trade. They had one boy who had been with them about 15 months, and he was now able to earn 14s. a week, whilst there were few men able to earn more than 16s. or 17s.

Mr. Campbell (Principal of the Normal College, Norwood) said he would say a word or two on the question of type; as a rule he had been careful to say as little as possible on this vexed question, but rather to use such materials as he had to promote the education of the blind; but still the matter was now in such a condition that it was only fair to give publicity to the facts as they were. The Braille system was a little misunderstood; for instance, the Chairman seemed to think there would be a difficulty with the parents and friends, but he had sold some hundreds of writing frames to the pupils to send to their friends, so that they might correspond with them. Nor did he anticipate the difficulty which some did with regard to sighted schools. He hoped the instruction given in the lattter would be of such a thorough character that the children would soon pass beyond the stage of merely learning their letters, and then that would be the most useful system which would make them differ least from their companions. In their school, if they had anything to learn, like geometry, grammar, or any science whatever, the pupils wrote it down very rapidly, and then they had their own instruction books. A circumstance occurred that afternoon which would illustrate what he meant. Dr. Armitage paid for several pupils every year in the Normal College—and he must add that he always travelled third-class that he might have more money to spend on benevolent objects—and he said he should like to have specimens of the writing of these pupils for whom he was paying. That afternoon one of the pupils asked what he should write, saying he should like to write something useful, and when he told him to write what he liked, he said he would write some nice copies of poems from the Boston type, which could be stereotyped. That afternoon there were four blind pupils stereotyping at the College. This type was also applicable to music notation, which could be rapidly written and easily read, one of the boys the other day having been learning the "Hallelujah Chorus" on the organ. A visitor said he had no doubt he could write it down, when the boy immediately said, "I have already written it." Indeed, he could hardly conduct the educational department of the establishment without this system.

Mr. J. M. Blashfield said it had often occurred to him that the blind, having a delicate sense of touch, might be employed in the simpler operations of pottery; and also, that by means of sections of cones, cut so as to give the ellipse, parabola, and hyperbola, and placed on a flat surface, the blind would obtain such a knowledge of the principal geometrical lines as would enable them to imitate in pottery the fine curves of the old Greek vases.

The Chairman then moved a cordial vote of thanks to Dr. Armitage, which was seconded by **Major Fitzroy**, and carried unanimously.

GENERAL NOTES.

African Exploration.—It is announced that a public meeting will be held at Preston, in Lancashire, on Monday next, the 10th inst., to discuss the question of opening up Central Africa for purposes of trade and commerce. The special object of the meeting is to provide fresh markets for the productions of Lancashire. The principal originator of the movement is Mr. Bradshaw, who has undertaken to bring the same subject before the Society, at the meeting of the African Section on the 18th March.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at Eight o'clock:—

FEBRUARY 12.—"The Application of the Bessemer Process to the Reduction of Metallic Sulphides." By JOHN HOLLWAY, Esq. Professor ROSCOE, F.R.S., will preside.

FEBRUARY 19.—"Turkish Resources and their Ready Development." By J. L. HADDAN, Esq., M I C.E., ex-Chief Engineer in the Ottoman Service. Lieut.-Gen. Sir A. B. KEMBALL, K.C.S.I., C.B., R.A., will preside.

FEBRUARY 26.—"Indian Pottery at the Paris Exhibition." By GEORGE BIRDWOOD, Esq., M.D., C.S.I.

MARCH 5.—"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By JOSEPH J. POPE, Esq., M.R.C.S., L.S.A.

MARCH 12.—"The Compensation of Time-keepers." By EDWARD RIGG, Esq., M.A.

MARCH 19.—"Economical Gardens for Londoners." By W. MATTIEU WILLIAMS, Esq., F.R.A.S., F.C.S.

MARCH 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor BARFF, M.A.

APRIL 23.—"English Freshwater Fisheries." By J. WILLIS-BUND, Esq., Chairman of the Severn Fishery Board.

CHEMICAL SECTION.

Thursday Evenings, at Eight o'clock.

FEBRUARY 13.—"Noxious Vapours, with Special Reference to the Report of the Late Commission." By A. G. PHILLIPS, Esq., F.C.S., Assoc. Royal School of Mines.

MARCH 13.—"The Injurious Effects of the Air of Large Towns on Animal and Vegetable Life, and on Methods Proposed for Securing Salubrious Air." By W. THOMSON, Esq., F.R.S.E.

AFRICAN SECTION.

Tuesday Evenings, at Eight o'clock.

MARCH 18.—"The Exploration of Central Africa." By J. BRADSHAW, Esq.

APRIL 1.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By EDWARD HUTCHINSON, Esq., Lay Secretary of the Church Missionary Society.

APRIL 29.—"Some Remarks upon an Old Map of Africa contained in Janson's Atlas, published at Paris in 1612." Communicated and exhibited by R. WARD, Esq.

CANTOR LECTURES.

The Second Course will be by Dr. W. H. CORFIELD, M.A., on "Dwelling-houses: their Sanitary Construction and Arrangements." It will consist of Six Lectures, to be given on the following dates:—

LECTURE I.—FEBRUARY 17.

Situation and Structure of House.—Drainage of soil, foundations, walls, roof, rain-water pipes, &c.

LECTURE II.—FEBRUARY 24.

Ventilation, Warming, and Lighting.—Size of rooms, overcrowding, ventilators, stoves, lights, &c.

LECTURE III.—MARCH 3.

Water Supply.—Sources, systems of service, cisterns, pipes, filters, &c.

LECTURE IV.—MARCH 10.

Removal of Refuse Matters.—Dust, kitchen refuse, earth-closets, &c. Conservancy and water-carriage systems compared.

LECTURE V.—MARCH 17.

Sewerage.—Main sewers and house branches, traps, ventilation, &c.

LECTURE VI.—MARCH 24.

Water-closets, Sinks, and Baths.—Arrangements of pipes, traps, &c.

N.B.—The Course will be illustrated by specimens and models from the Parkes Museum of Hygiene.

The Third Course will be by Mr. W. H. PREECE, on "Recent Advances on Telegraphy." It will consist of Five Lectures, to be given on the following dates:—

April 21, 28, May 5, 12, 19.

ADDITIONAL LECTURES.

Monday Evenings, at Eight o'clock. "Some Further Researches in Putrefactive Changes." By Dr. B. W. RICHARDSON, M.A., LL.D., F.R.S., in continuation and completion of his course of Cantor Lectures given last Session.

LECTURE II.—FEBRUARY 10, 1879.

The Preservation of Animal Matter, and the Comparative Value of Animal and Vegetable Food.

The regulations as to admission to these Lectures are the same as for the Cantor Lectures.

Members can admit TWO friends to each of the Ordinary and Sectional Meetings, and ONE friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

MON......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Additional Lectures.) Dr. B. W. Richardson, "Some Further Researches in Putrefactive Changes." (Lecture II.)
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. 1. Mr. T. J. Comber, "Explorations Inland from Mount Cameroons, and Journey through Congo to Makuta." 2. Capt. Patterson (the late), "The Bamangwato Country, South Africa."
British Architects, 9, Conduit-street, W., 8 p.m.
Medical, 11, Chandos-street, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Prof. Monier Williams, "Indian Home Life."

TUES.... Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture V.)
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Discussion on "The Geelong and Sandhurst Water Supply."
Photographic, 5A, Pall-mall East, S.W., 8 p.m. Annual Meeting.
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Capt. W. E. Armit, R.N., "Customs of Australian Aborigines." 2. Mr. D. Macallister, "The Australian Aborigines."
Royal Horticultural, South Kensington, S.W., 1 p.m.

WED. ... **SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. John Hollway, "An Application of the Bessemer Process to the Reduction of Metallic Sulphides."
Graphic, University College, W.C., 8 p.m.
Microscopical, King's College, W.C., 8 p.m. Annual Meeting.
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Mr. J. W. Redhouse, "The History, System, and Varieties of Turkish Poetry, Illustrated by Selections in the Original and in English Paraphrase."

THUR....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Chemical Section.) Mr. A. G. Phillips, "Noxious Vapours, with Special Reference to the Report of the late Commission."
Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 7 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Tyndall, "Sound." (Lecture I.)
Royal Historical, 11, Chandos-street, W., 8 p.m. 1. Mr. Henry H. Howorth, "Early History of Russia and Sweden." 2. Major-General Allan, "Historical Memorials of the Bishopric of Man and the Isles, 1305-85."
Royal Society Club, Willis's-rooms, St. James's, S.W., 6 p.m.
Mathematical, 22, Albemarle-street, W., 8 p.m. 1. Prof. H. J. S. Smith, "A Modular Equation on Prof. Cayley's Formula, and on the Formula for four Abelian Functions answering to the Formula for the four Theta Functions." 2. Monsieur Halphen, "The Number of Conics which Satisfy Five Independent Conditions." 3. Sir J. Cockle, "Construction of Magic Squares." 4. Prof. Henrici, "Notes on Frames."
Royal United Service Institution, Whitehall-yard, 3 p.m. Captain J. Templer, "Military Balloons."
Royal Institution, Albemarle-street, W., 3 p.m. Weekly Meetings, 9 p.m. Prof. G. Johnstone Stoney, "The Story of the November Meteors."
Astronomical, Burlington-house, W., 8 p.m.
Clinical, 53, Berners-street, W., 8½ p.m.
New Shakespeare Society, University College, W.C., 8 p.m. 1. Mr. J. N. Hetherington, "The Growth of Shakspere, as witnessed by the Character of his Fools." 2. Dr. Brinsley Nicholson, "The Relation between the First Quarto (1600) and First Folio copies of 'Henry V.'"

SAT.......Royal Institution, Albemarle-street, W., 3 p.m. Mr Reginald W. Macan, "Lessing." (Lecture II.)

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,369. VOL. XXVII.

FRIDAY, FEBRUARY 14, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

TECHNOLOGICAL EXAMINATIONS.

The following letter has been addressed to Lieut.-Col. Donnelly, the Director of the Science Division of the Science and Art Department, from the Society of Arts:—

DEAR SIR,—With reference to our conversation the other day, I am now able to inform you that sufficient funds will be provided by the City Companies for the payment of teachers of classes for instruction in Technology, on the same scale as that on which teachers of Science classes are now paid by the Science and Art Department, and without any proportionate reduction, as stated in the Society's Programme of Examinations (page 14), on the ground that the amount at the disposal of the Society might be insufficient to allow of the full payment in all cases.

Might I ask if you will be so good as to bring this important fact under the notice of the Secretaries of Science Classes and Schools, and to inform them that the arrangement will apply to the Examinations held in May next.

I have also to request you to inform them at the same time that it is of great importance we should be at once informed of the number of classes likely to be formed before our next Examination.

I am, dear Sir,
Your obedient servant,
H. T. WOOD,
Assistant-Secretary.

In consequence of this communication, a circular has been issued by this Department to Science and Art Schools and Classes, requesting that notice may be sent of the formation of any classes in Technology, with the number of pupils attending them, and the probable number that will come up for examination in May next.

NATIONAL WATER SUPPLY.

The Council of the Society of Arts have determined to offer the Gold Medal of the Society, and three silver medals, for the best suggestions, founded upon evidence already published, for dividing England and Wales into watershed districts, for the supply of pure water to the towns and villages in each district.

The suggestions must be sent in to the Society's office, on or before the 26th April, so as to be discussed at the Conference on Health, in May.

The details of the conditions will be issued immediately, and may be had, when ready, on application to the Secretary of the Society.

SAVING LIFE AT SEA.

The report of the Committee upon the Apparatus sent in in competition for the Society's Medal, is now ready, and can be had on application to the Secretary. It will be published in the *Journal* as soon as space permits.

CANTOR LECTURES.

MATHEMATICAL INSTRUMENTS.

By W. Mattieu Williams.

LECTURE VI.—MONDAY, JANUARY 27, 1879.

We have seen how the theodolite, the sextant, and kindred instruments, enable us to measure unclimbed heights by looking upwards, and we now come (much later than I proposed) to the instruments by which we may measure the heights we have actually climbed. The level, the barometer, the sympiesometer and the hypsometer are the most important of these.

I need scarcely describe the spirit level or bubble tube, so commonly used for determining horizontal lines and planes. Everybody knows that it is a tube partially filled with liquid, and laid down so that the bubble of air may stand in the middle when its position is horizontal. This tube is variously mounted, according to the uses to which it is to be applied. The carpenter, the cabinet-maker, the billiard table mounter, &c., have it set in a box frame, in order to lay it directly upon their work; others use the bare tube ground flat at its lower part. The accuracy of the mounting of any of these should be tested by placing it on a surface that throws the bubble to the middle of the tube, and then reversing it; the bubble should retain its position. In the instruments I am about to describe, it is attached to a telescope in such a manner that it shall indicate the horizontality of its optical axis, like the upper level of the Y theodolite.

Though the common bubble tube is well enough understood by all, there are some features in the construction of delicate instruments that require explanation. Why "spirit level" rather than water level? may be asked at starting, seeing that the flow of all liquids to find their level is the essential principle upon which the instrument acts. As I have never met with any answer to this question, nor even heard it asked, I must give you my own theory, in explanation of the experience of much antiquity which has shown that an alcoholic liquid is far better than water.

Fill a glass or tube with spirits of wine or strong whisky, and another with water; then pour the liquid from each by inversion, and examine the glass. That which contained the spirit will be found less completely emptied than that which held the water,

and the reason will be evident on further examination, as the sides of the spirit glass will show beads and strings of liquid adhering to it. This adhesion cannot be instantly overcome by a slight force, and thus the bubble travels more slowly than it would if the tube were filled with water. This slowness of travelling gives warning for readjustment, and renders the instrument more manageable. The lower specific gravity of the spirit of course tends in the same direction, but I attribute the difference mainly to the difference of adhesion.

For common spirit levels the glass tube is used as it comes from the tube drawer, but the bubble tubes attached to well constructed mathematical instruments are ground on their inside, by rubbing them with emery powder and water on a brass cylinder that has been bent to a circular curvature. The object of this is to give a similar curvature to that part of the tube under which the bubble travels.

It is evident that if this part of the tube were quite straight, the smallest possible inclination would cause the bubble to run at once from one end of the tube to the other, and if the tube were curved with a convexity downwards, the bubble could not be retained in the middle at all. By giving it a slight arched curvature, the bubble may be made to rest firmly in the middle of the tube, and by regulating this curvature, the travelling of the bubble may measure small angular deviations from the horizontal line.

The best levels are ground so that the tube, or a scale attached to it, may be divided to given fractions of a degree, a minute, or even of a second, as required. The range and regularity of the travelling of the bubble is determined by an instrument commonly named a "bubble trier."

It is simply a brass or wood ⊢ shaped stand, with screws at each of the three ends passing through and forming a tripod, when the **T** is lying horizontally. The screw at the end of the long stem of the **T** has a micrometer head, by which the level of the stem may be adjusted, and any elevation or depression measured in seconds and fractions of seconds. The tube rests on **V** shaped supports on the stem of the **T**. Thus the tube may be raised or depressed through known angles of arc, and the travelling of its bulb for any given inclination may be ascertained. The grinding of a good level is a rather tedious job. It has to be continually filled and tried, and emptied and ground again, in order to obtain regularity of curve and the range demanded.

The bubble tube being the fundamental element of the levelling instrument, great care has to be devoted to its construction. It should be as long and as well ground as possible.

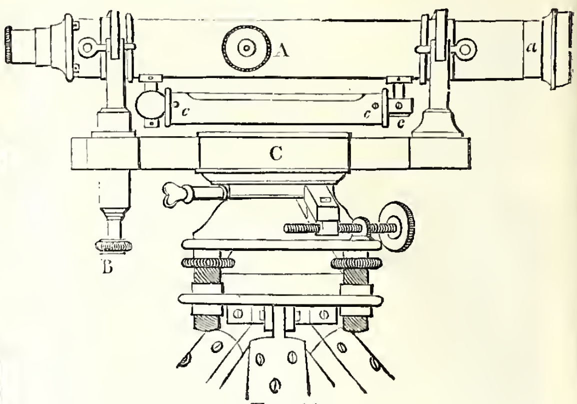


Fig. 21.

The old form of **Y** level is shown by Fig. 21, where

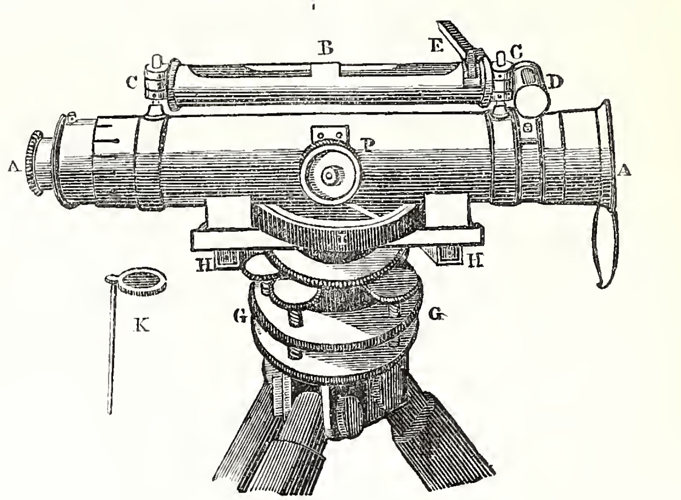


Fig. 22.

A is the telescope mounted on **Y**'s, like the theodolite already described. The vertical axis or centre, screwed by a flange to the limb, C, works in a ball that rolls on the socket of the upper parallel plate, and has a clamp and tangent screw, all of the same construction as the **Y** theodolite. This is also the the case with the parallel plates themselves, and the staff-head which carries them. Fig. 22 is Mr. Gravatt's, or the "dumpy level." Fig. 23 is a modern form of the **Y** level, called the "dumpy **Y**," and Fig. 24 is the Troughton and Simms's pattern of fixed telescope level.

The limb, C, may be made with or without a compass. When it has a compass, and the tangent

screw fine adjustment, the instrument becomes a circumferenter as well as a level; horizontal

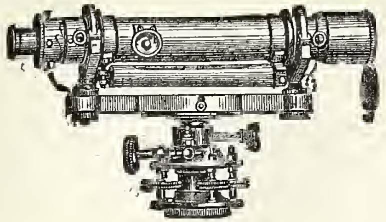


FIG. 23.

angles being measurable, within certain approximation, by comparing the compass readings between any two objects when they are re-

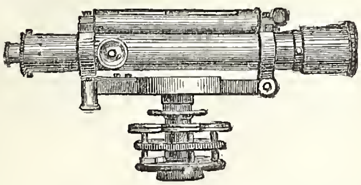


FIG. 24.

spectively sighted by the telescope; the difference measuring the angle required. The adjustment of the line of collimation in the Y level is obtained by rotation of the telescope on its collars as already described for the Y theodolite. The parallelism of the level to the line of collimation is also obtained in the same manner, by reversing the telescope end for end on its Y's.

To set the telescope, and its now parallel level, perpendicular to the vertical axis, the telescope should be brought over two of the parallel plate screws, and the bubble brought to the middle of its tube by these; now the instrument should be turned just half round on its vertical axis, and if the bubble remains in the middle of the tube, the adjustment is complete; if not half, the error must be corrected by the screw, B, moving the up and down piece, and the other half by the parallel plate screw. Then turn a quarter round over the other two screws, and repeat adjustment if required, until the bubble stands in the middle of the tube during a whole revolution of the instrument.

The adjustments of the other instruments with fixed telescopes, Fig. 22 and Fig. 24, are not so simple, but they have the advantage of being more permanent, so much so, that being once well made by the instrument maker when the instrument is new, many surveyors rely upon their continuance. This, however, appears to me to be a dangerous practice, as instruments are often carried by clumsy extemporised assistants, and may be dropped as readily as babies are by nurse girls. All the adjustments are easily obtained by the instrument maker. He has two watch dials or other suitable objects placed exactly on the same level, and in opposite or considerably seperated directions from his observatory. After optically adjusting the telescope, correcting parallax if any, he places the instrument with the centre of its telescope on the same level as these objects, and makes the above-named adjustments so that the horizontal collimating wire shall cut both, while the bubble remains in its place during the turning of the instrument. Or a single distant mark may be used if the optical axis of the instrument is fixed on the same level, which is easily determined by having a nearer object previously levelled to the distant one, and making both coincide with the collimating wire. The two objects cannot be defined at the same moment, as the telescope must be separately focused to each. In this case the bubble must be watched to see whether the elongation and withdrawing of the telescope throws it out.

It should be understood that the level only demands adjustment for vertical collimation, that is, the collimation indicated by the horizontal wire or spider line. The fixed level points, or test objects of observation, whether used as above or otherwise, are previously obtained by means of a Y level in perfect adjustment.

Or a Y level in perfect adjustment may be used as a collimator thus: Place the collimator and instrument to be adjusted at some distance from each other, as nearly as possible at the same height, and with their object glasses facing. Then level the collimator, focus its telescope to a distant object, and remove the eye-glasses. Now, direct the instrument to be adjusted so that you may look down the tube of the collimator and see its collimating wire, or more correctly speaking, see the horizontally projected image of its field and wires. It is evident that this can only be done when the optical axis of both telescopes are in the same line, and as the axis of the collimator was set to horizontality, that of the other instrument must be the same when the collimating wires of both vertically coincide. The telescope being now horizontal, see whether this is indicated by its bubble standing in the middle of its tube and continuing there during a rotation on the vertical axis. If not, adjust it by the means above described.

The surveyor in the field, who cannot thus command such fixed level stations and collimators, has to adopt other devices, the commonest being to select a tolerably level piece of ground, and, after levelling the telescope by the parallel plate screws, direct it to a staff held by an assistant some 10 or 20 chains distant. The height it reads above the ground, and that of the centre of the telescope, are measured, and the difference noted. Then the instrument and staff change places, and the observation is repeated. If the instrument correctly reads this difference of level on the staff it is in adjustment, *i.e.*, the level and line of collimation, or optical axis, are parallel.

A sheet of water may be used in like manner, but I confess that I decidedly prefer the Y level, which may be easily verified at any moment, and should be at the beginning of every day's work and after any rough handling.

At the time of the railway mania of 1846 I did some practical levelling. I had a level made according to my own design, and called it a "dumpy Y level," its object being to combine the reversibility of the Y level with the stability of the dumpy level. It worked satisfactorily to myself, and I showed it to Mr. Brunel, who also commended it; but I had no further occasion to use it, for the

"Direct Exeter" railway on which I was employed was a swindle, paid me neither for work done nor expenses out of pocket; my career as a surveyor, like that of many others of that period, ended abruptly in disgust, and the level was sold and forgotten, until in preparing the material for these lectures I found it immortalised as a stock pattern, bearing the name I gave it, "The Dumpy Y Level," and nearly the same in shape and detail. It is shown in Fig. 23 from the catalogue of Messrs. Troughton and Simms. Somebody else has evidently re-invented it, and it appears to enjoy some degree of practical favour. My instrument had for its Y adjustment the capstan headed screws (pushing and pulling), inside the protecting boxes, like those of Gravatt's level, H, Fig. 22, and the base of the Y's were solid blocks, like those which support Gravatt's telescope, and were previously used by Troughton. Facility and stability of adjustment were thus combined.

The same objects have been attained by Mr. Cushing in his level, where the principle of reversion is obtained by an interchange of the eye end with the object end of the telescope. Both slip on to either end of the tube, and are held by a sort of bayonet fastening, and may be clamped in their places. The telescope is fixed on blocks, and the blocks have a limited range of motion on the stage as in the Troughton and Simms' pattern level.

Mr. Cushing obtains the adjustment of the line of collimation (equivalent to the rotation on the collars of the Y level) by reversing his collimation stop, which is a glass disc with lines engraved upon it by a fine diamond, instead of spider lines. The parallelism of the level with the optical axis is determined by reversing the eye and object end as already described, and the other adjustments as in other instruments. A little light is of course lost by the reflection and absorption of the glass plate on which the collimating lines are drawn, but against this we have the far greater security against damage to this essential element, a damage not easily repaired in localities remote from the instrument maker's workshop. Without this security the reversal would be too dangerous for practical work, as the collimating stop has of course to be reversed with the eye glasses.

Rougher and cheaper instruments are used for such purposes as agricultural drainage.

I have made a very cheap instrument, for rudely indicating which objects in a landscape are level with myself, by simply fitting short pieces of glass tube to each end of an india-rubber tube of about 3 ft. in length, then bending the india-rubber in U shape, with the glass terminal tubes together, and filling it with water. By grasping one of the end tubes in each hand, extending one arm forward, with the glass tube upright, and holding the other near the eye, the slope of distant hill, or other object, may be sighted across the two level water surfaces, as in presenting a gun.

The reflecting level answers the same purpose. It is a small sighting tube, with a bubble tube set above it, and so arranged that the bubble is seen through the bottom of its tube, and reflected by a mirror into the sighting tube.

The chief use of levelling instruments is to determine the height of different stations, along a given line of country, above or below a given horizontal line usually called the "datum line." This may be the sea-level, or an arbitrary horizontal line, or some special elevation, such as the surface of a reservoir, or lake, or river, that is to be used as feeder to a canal, or for water supply to a town. The mode of proceeding is virtually the same in all cases. The leveller is usually supplied with a detailed map of the country, on which the line he is to follow is marked, or the line is marked upon the ground for him, or otherwise indicated. He starts from a given station, the height of which may be taken as his "datum," or the height of which, above or below the required datum, is already known.

He measures a certain distance along this line from his starting station or "bench mark;" an assistant holds a tall staff divided into feet and tenths of feet from the ground upwards, at each end of the line thus measured. The level is set up between these—midway or thereabouts. The observer turns the telescope of his adjusted level to the starting place, and notes the reading on the staff there, which reading of course shows the height of the optical axis of the instrument above the ground on which the staff stands. He calls this reading the "back-sight." Then he turns the telescope upon its vertical axis to the other staff and reads this. This reading, which is the height of the same optical axis above the second station, he calls the "fore-sight." It is evident that the difference between these two readings give him the difference between the height of the ground on which the two staves are respectively standing.

The first staff is now done with, so far as its first position is concerned, and it is accordingly removed, while the second staff, which supplied the fore-sight of the first pair of observations, is merely turned half round, but otherwise carefully retained in its position. From this position another measurement is made, at the end of which the staff just removed from the starting place is set up, and the level, as before, is stationed between them.

It is evident that the staff and station which first supplied the fore-sight will now supply the back-sight, and the staff which has been carried forward will supply the fore-sight of a second pair of observations.

In the diagram, Fig. 25, A may represent the start-

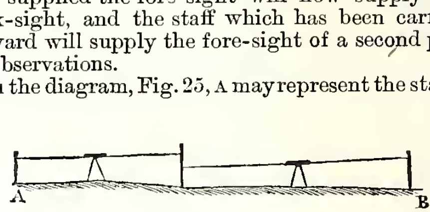


Fig. 25.

ing place, and B the third station, that which the staff was carried when taken from its first position at A. It will be seen that the height of the level itself is immaterial, provided its line of sight does not overstep the top, or reach the ground below the foot of either staff.

Let us now suppose that the starting point was 20 feet above the datum line, the distance first measured was 3 chains, the first back-sight read 5 ft., and the first fore-sight 6·3 ft.; that the second measurement was 4·8 chains, the second back-sight was 3·5 ft., and the fore-sight 7·2 ft.; the surveyor might thus book his results:

No. of Station.	Distance.	B.S.	F.S.	Difference of Level.	Height above datum.	Remarks.
1	..	..	..	..	20 ft.	
2	3·0	5·0	6·3	—1·3	18·7	
3	4·8	3·5	7·2	—3·7	15·0	

The above is a very simple form of field book, which I give to show the principle. It may be modified and complicated considerably. If compass bearings are taken, a column must be added, and the "Remarks" column (desirably wider) may take in notes respecting objects passed, or any peculiarities of ground that are worthy of note. It is evident that, if the fore-sight reading exceeds the back-sight, the difference of level is minus; if *vice versâ*, it is plus, and must be set down in the 5th and 6th columns accordingly.

From such a record a section of the country may easily be made by simply drawing the datum line horizontally on paper, laying down upon it the distances entered in second column, setting up above these the heights given in sixth column, and connecting the points thus set up.

The distances chosen from station to station depend upon the accuracy of detail demanded, and upon the nature of the country, If the ground slopes very slightly, and without irregularities, the distance may be extended to the reading limits of telescope. If there are great irregularities, up and down, observations must be made at short intervals, in order to show these irregularities in the section. If the slope is steep, the height of the staff limits the distance between the stations, and corrections must be made for differences between hypothenuse and base (see lecture 5).

In special levelling, such as for making the permanent way of a railroad, certain short, regular, and specially prescribed intervals have to be adopted.

In ordinary levelling over moderate distances, the horizontal line may be regarded as straight, but such is not actually the case; the surface of water upon the earth, or the line at right angles to the radii of the earth, is curved. Where great accuracy is demanded, correction is made for this, the surveyor being supplied with tables for the purpose. That it may be neglected in ordinary work will easily be understood, from the fact that in 100 feet it amounts to only 0·00024 of a foot. Thus in levelling over 1,000 feet in ten stages or stations, the error would amount to 0·0024 of a foot, but if the whole 1,000 feet were taken in one observation it would reach to much more, nearly ten times as much, viz., 0·02392 of a foot. The reason of this is easily shown by a drawing a circle and a horizontal line touching it. It will be seen that the length of the perpendicular that must be drawn to drop from the straight line to touch the circle (*i.e.*, the versed sine of the arc) increases with great acceleration as we proceed. Thus the shorter the distance between the stations, the smaller becomes the curvature error in levelling over a given distance.

The refraction is another minute source of error, but as far as it goes it operates in diminishing the curvature error when both are neglected.

Torricelli, following the footsteps of his master, Galileo, reasoned out the principles of the transmission of fluid pressure, and thereby showed that if a long tube be closed at one end, filled with mercury, and then inverted with the open end downwards, and dipping into a cup of mercury, the mercury in the tube will stand above the level of that in the cup, because it is pressed upwards by the downward pressure of the atmosphere upon the surface of the mercury in the cup, pressure on fluids being transmitted equally in all directions. His reasoning was disputed, and a long controversy ensued. This controversy was finally closed by the celebrated *experimentum crucis* of Pascal, who proposed that the question at issue should be tested by carrying the "Italian's tube" up a mountain. He maintained that if the height of the mercury in the tube depends upon and measures the pressure of the atmosphere, that height must be diminished as we ascend the mountain, inasmuch as in doing so we leave some of the atmosphere below us, and have less overhead to press upon the mercury of the cistern. The challenge was accepted, and Torricelli's tube was carried up the Puy de Dome, one of the volcanic mountains of Auvergne, with triumphant results.

The principle of this *experimenum crucis* has subsequently been practically applied to the measurement of the heights of mountains, elevated plains, table-land, &c., and the elevations attained by aeronauts. The height of the column of mercury at the sea level, or any station at known height above it, is taken, and this is compared with its height at the place of which the elevation is to be measured. Suppose the mercury column to measure 30 inches in the first, and 20 in the second, it is evident, if Torricelli is right, that one-third of the atmosphere has been surmounted in ascending.

If the atmosphere were an ocean of uniform density throughout, and subject to no fluctuations, nothing could be easier than this mode of measuring the height we had risen while still immersed within it: but no such uniformity exists. Air being compressible and elastic, the lower regions of the atmospheric ocean are denser than those above them, in proportion to the greater weight of the upper atmosphere that rests upon the lower. Besides this, the atmosphere is subject to a multitude of fluctuations or palpitations, some regular, others irregular, and thus its pressure at any given place varies considerably from time to time, and the height of the barometer varies with it. This variation from time to time renders it necessary that simultaneous observations be made at the upper and lower stations, in order to obtain accurate results.

The variations of atmospheric density, as we proceed upwards, evidently alter the value of any given depression of mercury as an unit for height measurement; that is, a fall of one inch between 30 and 29 does not indicate the same difference of height as a fall between 29 and 28 inches, because the atmosphere we pass through in ascending from a pressure balancing 30 to one balancing 29 inches of mercury is denser than that between 29 and 28. Therefore, as we ascend, any given fall of the barometer measures a continually increasing difference in elevation.

Time forbids me to enter further into this subject, or to attempt a demonstration of any of the barometric rules or formulæ in use, some of which are

rather complex. I will, however, give you the simplest I know, that of Leslie, which is as follows:—

Observe the height of the barometer at two stations; then, as the sum of these is to their difference, so is 52,000 to the difference between the height of the two stations, stated in feet.

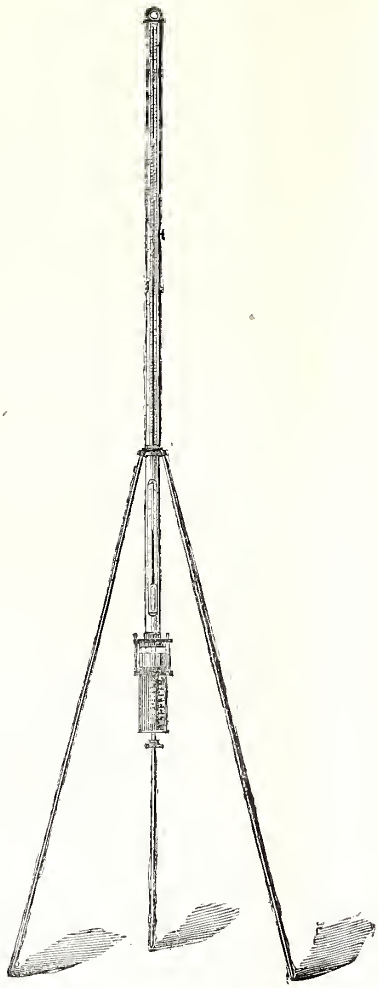
A well-known living mathematician, Mr. Alex. J. Ellis, has suggested a slight modification of this formula, by using the figure of 52,400 instead of 52,000. This, I believe, gives a nearer approximation to accuracy.

Anybody who can work a simple proportion—rule of three—sum can apply this.

Let us suppose that the barometer stands at 30 inches at the lower, and 25 at the higher, station. Then our problem is thus stated:—As 55 : 5 : : 52,400 : x. Multiplying the third term by the second, and dividing the product by the first, we obtain the fourth or x, which is the quantity required, viz., 4,763·6 feet. Now let us try the next five inches by this rule. Let us start from a station where the mercury stands at 25 inches, and climb up the mountain till it descends to 20 inches, we thus get 45 : 5 : : 52,400 : 5,600 feet for the second five inches, against 4,763·6 for the first. A third five inches, from 20 to 15, gives an ascent of 7,514·3 feet, and so on.

As the air and the mercury are unequally expanded by heat, a correction must be made for temperature. Tables are obtainable for this.

The mountain barometer is Torricelli's tube, rendered as portable as possible, and protected against external injury. One of its best forms is shown in Fig. 26, where the barometer is mounted on its portable tripod, and Fig. 27 shows the leather



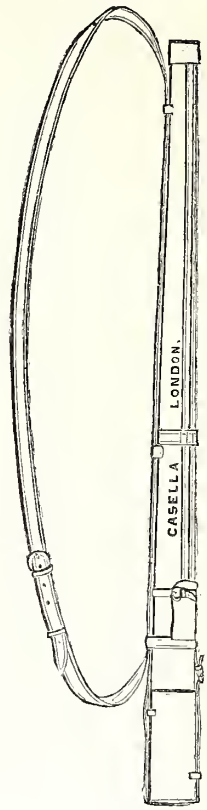


Fig. 27.

case in which it is packed and slung to the back of the traveller.

In spite of all the ingenuity of the Italian instrument makers, this is a cumbrous piece of luggage for mountain climbers. It must be above 30 inches long exclusive of the cistern, and it must contain troublesome mercury. This has led to instrumental substitutes for the mercurial thermometer, the most popular of which is the "Aneroid barometer," invented by M. Vidi, of Paris.

It consists essentially of a circular box, the face of which is made of thin elastic metal, rendered more elastic by being stamped or pressed into concentric circular wave-like corrugations. Half of this box is shown in Fig. 28. This is nearly ex-

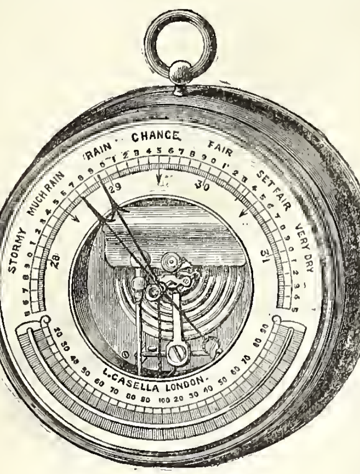


Fig. 28.

hausted of air, and its elastic face supports the pressure of the atmosphere, and yields to it with elastic resistance, in proportion to the amount of pressure. Thus, if the atmospheric pressure increases, the face is pressed inwards; if atmospheric pressure diminishes the elastic reaction of the metal, moves the face outwards. These movements are communicated to an index by suitable and very delicate mechanism, and registered in largely magnified dimensions, by the movements of this index upon the face of the dial.

Aneroid barometers are now made of pocket-size, compensated for temperature, and with double scales, one reading the height of the barometer column, the other the elevation obtained. I have used one of these during many years, and find it a very interesting travelling companion. It is sufficiently sensitive to indicate the ascent from the ground floor to the upper rooms of a three-storied house, or to enable the traveller sitting in a railway train to tell, by watching its face, whether he is ascending or descending an incline.

Such slight variations are more easily observed on the aneroid than on the mercurial barometer, and therefore it is commonly stated that the aneroid is the more sensitive instrument. This, however, is a fallacious conclusion. It is not the superior sensitiveness of the movements of the instrument, but the greater facility of reading them, that gives this advantage to the aneroid, the index of which has a needle point travelling nearly in contact with the foot of the divisions; the readings are further aided by a needle-point register attached to a moveable rim, which may be brought point to point against the index, thus showing the slightest movement that human vision may detect. A magnifying lens may be easily used in such a case. The mercury surface of the Torricelli barometer is a comparatively clumsy index. It is not flat, but bulges upwards and curves downwards when rising and falling, and the observer is deceived by parallax unless his eye is accurately level with the mercury surface when he is reading the scale.

It should be understood that the aneroid barometer is not an independent instrument; it is merely a device for representing the movements of the mercurial barometer. It is regulated by comparison with the primary instrument, and this comparison should be renewed from time to time, as the elastic properties of the metal may and do vary. An adjusting or regulating screw is attached to the back of the instrument, and is usually moveable by a watch key.

Besides this, the magnified reading of course magnifies any primary error, and is largely dependent on the accuracy of the mechanism.

The sympiesometer invented by Mr. Adie, of Edinburgh, in 1819, is a glass bulb filled with an elastic fluid (hydrogen gas was used by the inventor). This is blown on the upper part of a thermometer tube, on the lower part of which is an up-bend surmounted by another bulb which is open. This open bulb is partly filled with coloured liquid (almond oil tinted with anchusa root tincture) that rises in the tube to which a scale is attached. It is obvious that if the pressure of the atmosphere increases, the hydrogen will be compressed, and the liquid rise in the tube; if the atmospheric pressure diminishes, the elastic reaction of the the hydrogen will force the liquid down.

Variations of temperature have, of course, considerable influence on this instrument. It is, therefore, mounted with a thermometer attached, and the scale which reads the barometric heights is moved against a second scale marked with thermometric degrees, by which means the variations due to temperature are compensated.

Here I have another instrument, the hypsometer, acting on the principle that the boiling point of water varies with atmospheric pressure. Taking 212° Fahr. as the boiling point at the sea level with barometer at 29·92 inches, it falls to 211° at an elevation of 519 feet, and barometer at 29·33 inches; to 210° at 1,041 feet; to 200° at 6,376 feet, to 180° at 17,615 feet and 15·27 inches, and so on.

The hypsometer, shown Fig. 29, is a thermometer surrounded by a jacketed case, and so suspended that its bulb shall stand a little above the surface of some water in a small metal box or boiler, and thu be enveloped in vapour when the water boils. It is evident that the vapour will condense upon the bulb until the bulb reaches the condensing point of aqueous paper which, as already stated in the third lecture, represents a more constant temperature than that of boiling water.

In this instrument there is a further advantage in this position of the bulb, viz., that any available water, whether clean or dirty, salt or sweet, may be used; as the condensed vapour is of course always distilled water.

The thermometer has a small bulb, is strong and sensitive, and is divided to 0°·1 on its stem, and is sheltered from cold when in use by the double telescope chamber. It should not be inserted quite so deep as in the figure, and the stem, which is held by a loose indiarubber cover, may be raised to read the divisions. A wine-glassful of water and half as much spirits serve

for several observations. It closes like a telescope to fit in a case, Fig. 30, and is now made of pocket size by Mr. Casella, with thermometer graduated to 0°·2, but easily readable to one-tenth of a degree less.

This instrument has the advantage of depending directly upon, and directly displaying the natural action without intervening mechanism. Unless actually broken, it cannot get out of order. Tables for reduction to altitude, with correction for temperature, and for decrease of gravity, are obtainable with this elegant little instrument.

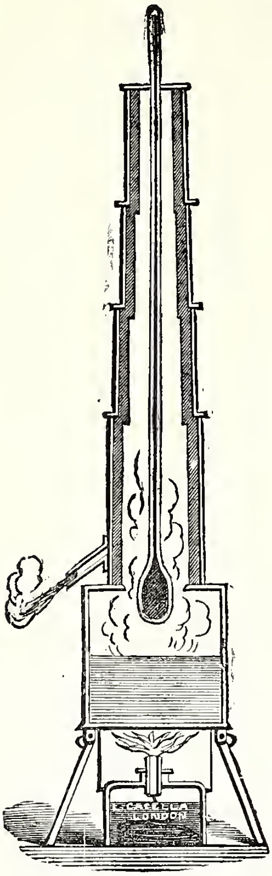


Fig. 29.

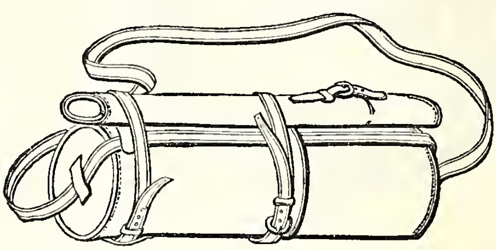


Fig. 30.

It was my intention to have taken up the subject of the balance and other instruments for measuring gravitation, also the measurement of minute quantities, and that of drawing instruments; but time has not permitted me to include these without doing great injustice to all the other subjects I have treated.

The illustrations for this lecture were a level of Troughton and Simm's pattern, and reflecting level, lent by Messrs. Troughton and Simms. Mr. Cushing's reversible level, a Sopwith's levelling staff, and Mr. Crossley's new levelling staff, lent by Mr. Cushing. A Y level, aneroid barometers, and hypsometer, lent by Mr. Casella. Also a case of German drawing instruments, lent by Messrs. Ahrbecker and Son.

AFRICAN SECTION.

Tuesday, February 4th, 1879; Colonel Harley, C.B., C.M.G., in the chair.

The Chairman, in commencing the proceedings, said he regretted to have to announce that, owing to unforeseen circumstances, Mr. Cotterill could not be present to read his paper, but it would be read by Dr. Mann, the secretary of the Section.

Dr. Mann, in accordance with the Chairman's announcement, and in obedience to his request, proceeded to state that before reading the paper, which had but just been placed in his hands, he thought it advisable, with reference to the maps, to give a few explanatory words regarding Mr. Cotterill himself, and the gallant explorer who was his associate and comrade, through a large part of the adventurous expedition alluded to in the paper which was to be read.

MR. COTTERILL'S EXPEDITION TO LAKE NYASSA.—INTRODUCTORY REMARKS.

By Dr. Mann, M.A., F.R.C.S.

It will be remembered that, on the 28th of May last, Mr. Cotterill read a paper, at a meeting of the African

Section, "On the Nyassa; with Notes on the Prospects, Commerce, and Colonisation of the Neighbourhood." That paper resulted from an expedition which Mr. Cotterill made in the month of May, 1876. He then started, in company with a party of missionaries bound to Livingstonia, on the southern shores of the lake, taking with him a small stock of merchandise, suitable for an experiment upon the commercial capacities of the neighbourhood. He also carried with him a ten-oared steel boat, 30 feet long, in separate compartments for the convenience of transport, which was a present to him, in token of sympathy in his undertaking, from friends at Harrow School. At the Cape the party chartered a small steamer to convey them, with their belongings, to Quilimane. They ascended the Quilimane river, the Kwakwa, as far as Karrokwe, and then crossed the land, by a passage of about four miles, to the Zambezi river, at Mazarro. They thence ascended the Zambezi, and its affluent, the Shire, to the well-known cataracts of this latter river, above which they were met by Mr. Young with the steam launch from Livingstonia. The steel boat was transported overland past the cataracts, over a portage of 55 miles, by 150 natives. It was then launched upon the upper Shire, and in company with the steam launch *Ilala*, proceeded to Livingstonia, the missionary station on the lake.

Six months of the rainy season were spent at Livingstonia. Trips were afterwards made on the lake to Tambala's residence, to Kota-Kota, and to Mankambira's place. Mr. Cotterill's last paper alluded chiefly to these expeditions. After his return to Livingstonia, Mr. Cotterill completed his preparations to carry out the main purpose of his trip, which was to attempt to establish a new route of communication between the north end of Lake Nyassa, and the sea on the the East Coast, somewhere between Zanzibar and Quilimane. In prosecution of this purpose, he went first to the cataracts of the Shire to engage men, and he there, in the month of August, 1877, met Captain Elton, who had just come out with the design of attempting some similar excursion. It was then arranged that they should join their resources and make the trip in company.

As this unfortunately proved the last journey made by Captain Elton, and as his share in the work has an interest of its own, a brief note in explanation of the career of this distinguished adventurer may here be advantageously made. He was the son of Lieut.-Colonel Elton who, at one time, commanded the 59th Bengal Regiment. The future traveller entered the Bengal service at the period of the Indian Mutiny. He was at the relief of Lucknow and Delhi, and received a medal for the service then rendered. In 1860, he joined the Chinese Expeditionary Force, and was present at the taking of Peking. In 1866, he joined the French army in Mexico, and served until the conclusion of the war, after the death of Maximilian. In 1868, he went to Natal, and the gold district of the Tati, north of the Limpopo. He descended the Limpopo to its mouth in a boat. The narrative of this bold and adventurous voyage is printed in the 42nd volume of the *Journal* of the Royal Geographical Society. In 1871, he was engaged in an examination of the gold and diamond fields of South Africa, and in a mission to the Portuguese settlements on the eastern coast. In 1872, he acted as Government agent on the Zulu border until he suffered from a severe attack of fever. He then became protector of native coolie labourers in Natal, and in the following year started for Mozambique and Zanzibar, to negociate a scheme for the establishment of a telegraph to Aden, for the supply of native labour to Natal from Delagoa Bay, and to meet Sir Bartle Frere. He was next appointed Vice-Consul at Zanzibar by Sir Bartle Frere, and made an excursion from Dar-es-Salam through the Copal regions to Quiloa, or Kilwa, which is described in a communication to the Royal Geographical Society, printed in vol. liv. of their *Journal*. In 1875 he was made British Consul in the Portuguese territories of Mozambique, and in 1877 accomplished a trip to the cataracts of the River Bomba from Mozambique. At this time he sent a somewhat voluminous MSS. to England, comprising "Notes and Sketches in East Africa, and Memoranda Relating to the Suppression of the Slave Trade, from 1873 to 1877." In March, 1877, he started for his last trip to the Zambesi, and shortly after this effected his junction with Mr. Cotterill, at the cataracts of the Shire.

Mr. Cotterill and Captain Elton left the station at Livingstonia, in company, in the steam launch *Ilala;* they first visited the east coast of the lake, and then crossed to the west shore under Mount Chombe. They ascended the mountain, which was found to be 4,000 feet high, and then proceeded on their voyage towards the north until driven by stress of weather to seek refuge in an inlet 9° 40′ south latitude, not far from the northern end of Nyassa. At Malisaka, a Wachungu village in this inlet, where they landed, they were said to be ten days' journey, or probably 120 miles distant from Lake Tanganyika. The principal man in the village, Mbungu, passed himself off for an influential chief, and managed to extract a present estimated upon that base.

The explorers proceeded onwards from Malisaka with 50 men, Mr. Cotterill being himself at that time ill, and carried at first in a hammock. The track led them through a long sketch of banana groves into the valley of the Chombaka river, which was crossed several times. They had to mount guard at night, to prevent the desertion of their men at this early part of the journey. There was here a great abundance of cattle, sour milk, and bananas. The natives dwelt in circular huts of bamboo and sun-dried brick, very neatly built. Having mounted a range of hills, they came in sight of the great plain of Uchingu, bounded at the further side by a chain of lofty mountains, which were obviously the continuation of the mountains forming the east shore of the lake—and there called the Livingstone Range by Mr. Young—setting across from its northern extremity towards the north-west. These are known by the natives as the Konde mountains. Several rivers ran across the plain towards the Nyassa; and the slopes of the hills were well cultivated, and very beautiful. At an elevation of 6,000 feet above the sea, Mazoti's place was reached, situated in a lovely country, in which the combination of cool mountain air, abundant herds and wild flowers, very strongly recalled the idea of the Switzerland. The hills around are, however, infested by a predatory tribe, known as the Makauka. The travellers were

finally deserted by their carriers at Mazoti's. After five days' hesitation and delay, Mr. Cotterill left the bulk of his baggage in Mazoti's charge, and started with only five men and a guide, carrying their blankets, guns, and a very limited supply of food. They climbed through forests of bamboo, until they at length traversed the Kondi mountains by a pass 8,800 feet high, and then emerged on the great plateau of Uwanje, 7,000 feet above the sea. Here they were met with rumours of war, and had to stop until a message could be sent on concerning them to the chief Merere. After a few days one of the chief's head men came back to them with an Arab from Suleiman Bin Abed, who resided with Merere. They then advanced, with an escort, to the edge of the plateau, and there had the vast plain of Usango, intersected by the Ruaha and other rivers, and stretching on down the Rufigi, before them. The Machinga were, however, in arms, and ravaging the whole country between this and Merere's. After a halt of some days, they at length organised an escort, and reached the Ruaha river, where they found Merere in a large strongly stockaded village on the further bank. This stockade was at the time undergoing a siege by 3,000 hostile Machinga. They were shut up in the stockade with Merere and Suleiman for some days, with bullets whizzing about their heads all day long, and with either an alarm or an attack at 4 o'clock every morning. In the early morning of November 5, the encampments of the enemy were full of blazing huts, and they were seen to be in full retreat. It soon afterwards appeared that a friendly party of Makangwala were said to be approaching for Merere's relief.

The baggage which had been left behind was now brought up, and Mr. Cotterill and Captain Elton employed themselves in shooting buffaloes and zebras for meat. But it was painfully apparent that Captain Elton was much broken in health on account of the privation which he had endured. The start was made from this place towards the north-west, because the more direct route which it was desired to take down the Rufigi was barred by the native wars and the disturbed state of the country. Merere's chief place, which stood upon the Mambi river, was found to be in ruins, having been burned down by Merere himself, because it was too large to defend. Mr. Cotterill's march from that lay across the head affluents of the Ruaha, across the mountain frontier of Usango Land, which was ascended by the gorge through which the Maharada affluent flows down. A large detour to the west was then made across the Niam-Niam country, which was abandoned desolate, all the cattle and people having been removed to the fastnesses of the mountains. The route lay over a finely-wooded hill country, with numerous deserted cattle stations scattered about. The mountain frontier was again struck at the sources of the Mzombe river, an important affluent of the Ruaha. The course of this river was then followed for some days with the accompaniment of famine fare. At one time two parrots were shot with the last cartridge. At length Mkongora's place, close to the 7th parallel of south latitude, was reached, and was happily found to be abounding in goats, grain, and honey. The path thence led through an undulating country of thick bush, the Uwambara land. Throughout this part of the journey Captain Elton was growing rapidly worse with malarious fever. The Makasumbi and Kasige rivers were crossed, and South Usekhe was reached, which was said to be only ten miles away from the frequented caravan road running between Unyanyembe and Zanzibar. This, however, proved to be the end of poor Captain Elton's pilgrimage. He remained quite unconscious for 50 hours there, and then sank under the exhaustion of the fell disease. He was buried under a large baobab tree, three miles from the native village. A caravan was at this time fortunately encamped at the well-known Usekhe station on the caravan route in Ugogo. Mr. Cotterill and three white companions reached this place in a nearly exhausted state, and were most hospitably received and entertained by the Arab, Hamram Selim. There now remained a march of 350 miles to the coast, but along the well-known route. There were the usual difficulties with the Wagogo, who always have a keen eye to travellers' tribute, to overcome. Mr. Thompson's party was met in Usagara lamenting over the loss of their draught oxen. A wet passage of the Mkata swamp was made, the travellers being occasionally chin deep in water. Her Majesty's ship *Vulture* was on the look out for them at Bagamoyo, and on the 4th day of February last year Zanzibar was reached, the surviving members of the party having traversed by water and land from Livingstonia, a distance of 1,000 miles in four months and a half.

In referring to this particular passage of his adventures in his communication last year, Mr. Cotterill remarked that "a great ox was standing upon his tongue." At that time he was engaged in preparing his comrade and friend Captain Elton's journals for the press. The great ox is at the present time happily upon the point of being almost immediately removed, by the publication by Mr. Murray of these journals, a large number of beautiful sketches and route charts, by Captain Elton, being comprised in the work. The ox is not yet actually gone, but the communication which is now to be placed before the meeting is an indication that it is about to move, and may be taken as a welcome first instalment of what may hereafter come before the Section from the same source.

THE OPENING OUT OF THE DISTRICT TO THE NORTH OF LAKE NYASSA, WITH NOTES OF A RECENT EXPEDITION THROUGH THAT COUNTRY IN COMPANY WITH THE LATE CAPTAIN ELTON, CONSUL AT THE MOZAMBIQUE.

By H. B. Cotterill.

In the present paper I had fully hoped to have been able to refer, by way of comment, to the description of our journey through Konde and Usango, given by my late friend and fellow traveller, Consul Elton, and to have elucidated my statements by means of his and my own maps of Nyassa and the region to the north of the lake. But the usual as well as unusual delays have occurred in the publication of these "Travels and Researches in Eastern and Central Africa," and I shall be therefore obliged to modify my programme to some extent. This evening I wish to

draw especial attention to that splendid region of Africa that lies to the north of the Nyassa, a region that, in company with Consul Elton and his friends, I have had the good fortune first to explore—a region which is at the present moment exciting some little interest from the fact that the Royal Geographical Society has organised an expedition to follow up our discoveries, in the hope (a hope that I think will be fully realised) of learning whether the vast table-lands of Usango will not prove, in point of healthiness, fertility, and accessibility, the most favourable site for the foundation of some considerable European settlement. In order to present my facts and theories in an intelligible manner I shall proceed thus:—First, I shall briefly state—as a thread on which to string the rest—a rough itinerary of my wanderings in Africa, then I shall treat of the general character of the various regions that I visited, the different tribes and their language, and finally offer a few remarks on what seems to me to be the most feasible of the schemes proposed for developing this part of the continent.

I entered Central Africa by the Zambezi, ascended to its tributary, the Shire, which flows from the Nyassa, spent a few months (from October, 1876, to March, 1877) near Cape Maclear, at the southern extremity of the lake; after the rains I made a fortnight's excursion westward, towards the Loangwa; in June I started in my steel boat, the *Herga*, hoping to reach the yet unvisited northern regions of the lake, but was compelled by the loss of my goods in a storm, and by the illness of my European boatman, to return after I had voyaged up the western shores to about lat. 11° 30', at very nearly the same point as was reached by Livingstone. On my return to the little mission station at the south of the lake (Livingstonia) I heard of the intended arrival of Consul Elton, and went down to the Murchison cataracts—some 150 miles below the Nyassa—in order to meet him. It was then decided by us that, if possible, we should (after he had made the investigations on the Nyassa, for which he had received official leave to visit the lake) endeavour to return to the coast by some land route. By far the easiest way to reach the Nyassa from the east coast is to ascend the rivers. The return journey is still easier. In a canoe (or rather in two, for there is a break of some 50 miles at the cataracts) one can descend from the lake to Quilimane in about 12 or 14 days. But we were anxious in the first place to learn the practicability of some other routes, and secondly, to investigate the doings of the Kilwa slavers, who were said to infest the caravan roads leading from Makanjila's and other depôts on the lake towards Lindy and Kilwa. The fact, however, that no one had as yet landed on the northern shores of Nyassa, and that the regions lying between the north end and the caravan route, from the coast to Tanganyika, were a *terra ignota*—and, lastly, the fact that an attempt was being made at that time to drive a road up from the sea towards these parts—made us decide to push up the lake as far as possible, and to endeavour to reach Zanzibar, or its vicinity, by striking towards the east from its northernmost extremity. The services of the little mission steamer were put at the disposal of Consul Elton, and, after a long and rather perilous voyage (for the *Ilala* is not large enough to face the great ocean roll of Nyassa, and the harbours are not numerous and not easily discovered by one sailing up the coast for the first time), when on the point of giving up in despair the possibility of finding any landing-place, we fortunately sighted a large inlet in about lat. 9° 40'. From this point (a village of the Wachungu, called Malisaka) we started towards the north, and crossed the grand range of Konde, which, after flanking Nyassa on the east, runs off towards the south end of Tanganyika. From the northern slopes of this range, or, rather, from the edge of the plateau of Uwanje (7,000 ft. above the sea), we looked down upon the great plain of Usango, watered by the Ruaha and the Ranga, which form a confluence with the Rufiji in a lake of a considerable size lying in the midst of the plain. The chief of the Wasango, Merere by name (of whom Livingstone had heard), was at this time at war. The marauding tribe of Machinga had driven off almost all his cattle, had forced him to evacuate and burn his great stockaded town, and were now devastating the whole country. Merere, with about 600 warriors, was making his last stand in a small stockade, or "boma," built on a bend of the Ruaha. It was with very great difficulty that we—those of us who had pushed on to reach Merere's being compelled to do so through want of food and the impossibility of obtaining carriers—that we could persuade the natives to allow us to descend into the plain, from which columns of smoke arose, testifying to the presence of the marauders. At length, Merere heard of our advent, and sent messengers and a strong escort, by whom we were taken, at the dead of night, through the lines of the besiegers, and found ourselves inside the densely-packed, evil-smelling "boma," closely invested by the Machinga. Several assaults were made on the stockade, and a great deal of terrible butchery was perpetrated by the enemy, who, on one occasion, through chagrin at an unsuccessful attack, speared about 80 women and children in sight of their friends and relations in the "boma." We were prepared to resist to the death had the Machinga once forced their way into our fortifications; but, though we were constantly rushing down, rifles in hand, our Wasango allies always repulsed the assault before we felt compelled to take part in the defence. After a siege of eight days, the Machinga burnt their camp, and went off towards the north-east, having been alarmed by the report that the Makangwāla were collecting their forces in the mountains in order to attack them in the rear. I shall speak of these tribes later. At present, I merely pass rapidly onwards. Leaving Merere (after a sojourn of about three weeks in that horrible stockade, the filth of which, and the evil odours arising from the numerous unburied corpses which tainted the air and poisoned the water that we drank), we pushed on northwards (it being impossible to strike eastwards on account of the Machinga). Here we found the country entirely depopulated. We passed many deserted villages, as well as the really extensive ruins of Merere's capital, which, as I said, he had been obliged to burn to the ground. This region, during certain months of the year, was roamed over and grazed by thousands of cattle; but, though we saw a great number of finely con-

structed cattle sheds, and large reservoirs at which they were evidently watered during the dry season, yet not a single live head of cattle, nor live head of man, did we see on that depopulated plain of Usango. Here game was plentiful, and we shot zebra, antelopes, and buffalo. It was indeed very fortunate that we were able to do this; for we had been obliged to start from Merere's with a very insufficient supply of grain, and had hoped to have been able to procure at least a small amount of "maëre" (diminutive millet) on the road. But of this there was no chance. All the people had left the country, and had driven off their cattle and removed all their grain to the mountainous regions of Usafa. After crossing the plain of Usango we reached the country of the Niam-Niams—a people of whom I shall speak later. Here, too, all the villages and cattle "kraals" were entirely deserted. It was with very great difficulty that, after a tramp of about 19 days, during which time we suffered very severely from the want of food, and sometimes from want of water, we reached a populated region. The people proved to be the Wawambara, and the first village which we reached was that of Mgongora, or rather that of Kagowa, for Mgongora (in alliance with Merere) had taken to flight, and Kagowa reigned in his stead. Here poor Consul Elton first showed signs of breaking down, and before we reached South Usekhe, the first village in Ugogo, his illness had taken a very serious form. At Usekhe, just as we had succeeded in reaching that Unyanyembe caravan road on which we expected all our troubles to end—and when our very last yard of cloth was now expended—he, after struggling for two days against the fatal power of African sun fever, died. The rest of our journey to Zanzibar, difficult and tedious as it was, does not sufficiently touch upon the question that I have set before me this evening to allow me to enter into any detailed narration. Suffice it to say that on the last day of January last year we reached the Indian Ocean, and were hospitably received by Dr. Kirk and others at Zanzibar, who were at the same time grieved at the sad news that we brought with us, and also not a little relieved by the contradiction that our sudden appearance gave to the reports of the loss of the whole party, which had found their way to Zanzibar and to England. Having now briefly traced the course of my travels, I will treat the various points that I mentioned in order. And, first, I shall say something on the general character of the regions through which I passed.

Of the lower rivers—the Zambezi and the Shire—I need hardly speak. The country through which they run partakes largely of the character of all that great malarious belt which encircles Africa on the seaboard, and which (except in the case of some isolated eminence, such as Mount Mosumbala) does not rise more than a few hundred feet above the level of the sea. Such a region is utterly uninhabitable by Europeans. It is true that the Portuguese do manage to exist at such places as Quilimane, and that at Mozambique and Zanzibar Englishmen and even English women bravely face the dangers of the climate for the ends of philanthropy, or even gain, but I can scarcely believe that any part but the highlands of the interior will ever be found habitable by the average European. It is not till one reaches the cataracts of the Shire that the first considerable rise in the general elevation of the country occurs. This point is about 300 miles from the mouth of the river, and it is this great stretch of malarious country which forms the one disadvantage to the river route. If one strikes due west across country from the sea an elevation of a thousand feet is reached within 100 miles—at least on some of the routes.

The mountain masses (Patamanga, Pinda, Zomba, and others) which rise around one as one passes through this region are of granitic formation. Here and there one finds an outcrop of white granite; in much of the rock there is a great quantity of mica, and now and then blocks of a crystalline character are seen. That gold might be found in this country is certain—indeed small quantities have been detected in the beds of streams—but whether it exists in sufficient quantities to repay the cost of machinery for crushing the rock, is not so certain. In the Shire valley, a little below the cataracts, the soil is exceedingly rich and fertile. One of the Makalolo chiefs, Ramokukán, cultivates several acres of cotton, which grows most luxuriantly. Sugar cane, bananas, &c., are to be procured in great abundance. Cattle and sheep flourish, the sheep of Ramokukán being the fattest and largest that I remember seeing in Africa. It may be remarked, however, that, though in certain spots in the Shire valley cattle can be kept with impunity, it is next to impossible to bring them thence up to the lake, for they are obliged to pass, on their journey, several places infested by the *tsetse* fly, and invariably die after reaching their destination.

The only possibility in the Shire valley, on account of its low level and its consequent unhealthiness (as, indeed, was too well proved by the disastrous termination of the Universities' mission), is this, that cotton, sugar, and perhaps indigo, might be grown there under the superintendence of native overseers, while the white planter should fix his residence among the hills which rise abruptly towards the east. He might be within a few hours' journey of his plantations (so much the less if he found it possible to import and use horses, or even mules), and yet be almost, if not quite, free from fear of malarious fever, and enjoy a most delicious climate.

The mountain ranges that flank the Nyassa on the south—toward the west the Umfata, and on the east Kinyanyombe—are almost entirely granitic. Very lovely they are, wooded to their summits with fine forest, and towering grandly above the dark blue lake with their huge precipices; but the general character of this region is anything but fertile. In some places, where a marshy country intervenes between the granite walls and the lake, or where the inflow of a river has heaped up delta of alluvial soil, native grain, batatas, rice, bananas, &c., grow well. But it is just these spots that are to be avoided by the white man. The consequence is that this beautiful country is hardly one which will ever prove very favourable for settlement. It is true that a little distance from the lake, towards the west (and from what Livingstone tells us, I should fancy also towards the east) there lie extensive plateaux, at an elevation of perhaps 3,000 feet above the sea, which are

fertile enough; but there were in the parts that I visited evidences of an excessive dowfall of rain during the wet season, such as would probably be detrimental to many kinds of crops. It is not till we ascend the west coast of the lake, to about lat. 10°, that this granitic formation gives way. At this point the great flanking range, that culminates in Mount Kuwirwe and Njoincho, bends off towards the north-west, and a huge limestone pile, Mount Chombi, borders the Nyassa. This mountain (which I ascended and found to be about 4,500 feet in height) rises on tiers of limestone precipices, blackened by the weather, but in parts bright yellow, where great flakes had peeled off the face of the cliffs. It is flat-topped, like Table Mountain; and was clothed with the most gorgeously tinted foliage from base to summit. In the lower valleys we noticed sandstone, shale, and slate, besides much yellow clay. The bright red clay, such as is used by the Kafirs for smearing their bodies, was seen by me in great quantities in some parts—for instance, near Kota-Kota.

The whole of the northern half of the Nyassa is incomparably more fertile than is the southern. About Mankambiras (11° 30') the native gardens exend over the hill-sides, sloping down to the water, and—instead of the poor crops of cassava or maize that surround the villages in the south—are filled with luxuriant vegetation—bananas, sugar-cane, yams, &c. It is, however, in the region actually to the north of the lake that the greatest fertility —or at least the most extensive and successful cultivation—is to be seen. The country that on the north and north-east is walled in by the great Konde mountains, rising to a height of about 12,000 feet, and on the south is bounded by the lake—a country called roughly "Konde"—once, at least, under the sovereignty of the Usango chief, Merere—this country is, without doubt, the most beautiful and the most fertile of any that I have seen in Africa. Consul Elton, who had been in India, declared that only among the Himalayas had he seen scenery to be compared with that of Konde. The people, of whom the largest tribe is that of the Wachungu, are in some respects rather "behind the age." For instance, they do not affect any pretence of dress—unless perhaps it be a bunch of leaves or grass, generally held in the hand. They build, however, the best huts that I have seen in Africa—using sunburnt oval bricks. They paint themselves with a white pipeclay in a most grotesque fashion—investing, for example, their legs and arms and half their face in a coat of white, and leaving the rest in its natural state. The country bordering the Nyassa is literally one great banana grove. For mile after mile one passes through long cool avenues overhung by the broad plantains and bananas—catching sight here and there, amid the forest of stems, of a neat little brick built or bamboo-woven, peak-roofed, hut. The Wachungu prefer to be warriors, and are armed to the teeth with barbed spears, the shafts of which are curiously inlaid with brass and copper wire. The iron, a very white metal (evidently containing a considerable quantity of tin) is procured from a mountain to the north of Konde, called the Mountain of the Makinga. Before passing from Konde to Usango, I might mention the mode of salutation that obtains among these people. Besides being, perhaps, philologically interesting, it is not a little ridiculous. A man will approach a group of his friends, squatted in the shade, and taking his seat beside them will gently pat his ribs. This is answered by responsive pats. He then diffidently remarks "Sokire" (a corruption of the Arabic "good morning.") The remark is re-echoed by his friends. He repeats it: they repeat it—faster and faster, till the word degenerates into "Soki," "soki," "soki," "so," "so," "so." . . . When all are panting for breath (this having continued for several minutes) one of the party will introduce a variation, "Aji," and off they will start on the new tack. "Aji," "soki," "aji," "soki," and so on, till the *tempo* becoming more and more rapid, the "Aji" becomes "A'—A'—A' —A'" . . . . . and at length a duet of grunts is instituted, which continues (sometimes actually to the accompaniment of a musical instrument) until all are thoroughly tired out. I have heard a morning salutation of this kind last for nearly half an hour.

As one rises, pass after pass, and ridge above ridge, towards the great backbone of Konde (the water parting between the Nyassa and the Rufiji system) one enters dense forests of immense bamboos. The flora at these elevations in Central Africa is very European in its character. Besides heaths, I noticed ranunculus, myosotis, cistus, willow herbs, geraniums, and many old friends. On the lower slopes of these mountains (on the Nyassa side) the timber of the forests is exceedingly fine, and straight in its growth. On the northern slopes, towards Usango, the trees are by no means so large nor so plentiful, being for the most part acacias, tamarinds, and the ubiquitous baobab. When the highest ridge is crossed, one finds one's self on a great table-land, extending northwards about 40 miles. This plateau of Uwanje is sparsely wooded, but watered by numerous streams, and is evidently a fine upland pasture ground for cattle. The River Wanje makes its way through a narrow gorge on the edge of this plateau, and falls into the Ruaha in the plain of Usango, which lies about 3,000 ft. below one as one stands on the precipitous verge of the upper valley. Usango and Uwanje are two of the great plateaux by which the traveller rises, step after step—500 ft. to 1,500 ft., 1,500 ft. to 3,000 ft., and thence to 7,000 ft.—towards the highest elevations of Central Africa.

The plain of Usango is by no means fertile, nor is it much cultivated. The greater portion of that which I traversed was of a poor soil, covered with low bush. In the wet season a great part of the plain is evidently flooded (as is the case also in Ugogo.) It teems with game, and is used as a grazing ground by the Wasango and Niam Niams, probably at the beginning of the dry season.

The Niam Niam country (a hilly region, at a level of about 5,000 ft. to the west of the great plain) was in its general appearance very like what one sees in parts of the Cape Colony—an undulating granite country with numerous "kopjies" (hillocks), and abounding in enormous ant-hills. This, varied by an arid swampy tract, is perhaps the commonest character of African scenery. In the more favourable regions the trees assume large proportions, and—except when the grass hides the prospect—the country reminds one of an English park. Beautiful as this ordinary

African scenery is, with its bright sward of freshly springing turf, its great timber, and its herds of antelope, zebra, eland, and elephant, yet the loveliness and grandeur of Konde is beyond all comparison more enchanting, especially to the fever-stricken traveller. I could hardly believe at times that I was actually in Africa. The flowers, the deliciously cool mountain air, the lowing and tinkling herds (for, strange as it may seem, the natives of Konde hang bells round the necks of their cattle), all these things made one fancy that he was in Switzerland, and the sudden appearance of a naked black figure was quite startling. The fields were laid out regularly, and in some places I saw hedges, an object that never met my eye in Africa before.

As regards the possibility of founding a settlement in Konde, and as to whether it will be possible to grow such crops as tea, coffee, sugar, and indigo, these are questions to which it is easier than it may be wise to give a decided answer. The present population is dense, and this might occasion some difficulties. The people are by no means easily persuaded to work for hire. Cloth, the common money of Africa, is almost unknown here, and little appreciated. Moreover, I do not profess to understand enough about tea planting and the like to enable me to form an opinion. A Mr. Bruce has written to me on this subject, and has asked me to give my opinion. I should far rather elicit his. He has heard (if he is present) that Konde is a fertile country, containing extensivsly cultivated tracts, that is well watered (indeed, perhaps, the rainfall is both violent and large), that it lies at an average elevation of about 6,000 feet, some parts of it, bordering on the Nyassa, being only 2,000 feet above the sea. I may add that the only peculiarity that I noticed in the soil, was that at one place (about the centre of Konde, in the Ruingero valley) the whole country was a mass of friable pumice-stone (or what I mistook for such, very light, porous, and of a dark colour).

I must now touch upon the various races.

In the south we have, as most know, the great race of the Manganja, which is partially under the dominance of another more warlike tribe (especially about the south parts of the Nyassa), called the Ajawaj, of whom there are two sub-tribes, the Wiao and the Machinga. On the south-west of the lake we find also the remnant of a small subject tribe called the "Kantundas," living in miserable little villages, and evidently in constant dread of enslavement. About lat. 12° 30′ (above the so-called "Arab" settlement of Kota-Kota) begin the Nyassa people—the Wanyassa, or Atonga. In the hilly parts, all up the western shores, are to to found bands of the marauding Zulus, who, on the Zambezi, are called "Landeens;" on the Shire, "Maviti;" and in these regions, "Mazitu," or "Mangoni." They domineer over the Wanyassa, stalking about their villages and taking whatever happens to strike their fancy. Of these Mangoni the Wakomanga (or "knob-nosed" Mangoni) are probably a subdivision. Besides these we have a people called the Afiani, who live to the west of Mount Chombi, and are said to possess much cattle, but have never been visited. The Wachungu, whom we first visited, possess a language in a few points resembling that of the Nyassa people, which is related to the Manganja. But so different are these various dialects that our natives could with difficulty make themselves understood. The Mangoni speak the Zulu language with so little variation, that a native from the Cape, who was connected with the mission, made himself intelligible to them. They told him that about 80 years ago their tribe had come up from Moscli-katze's country. They knew the name of the Limpopo, among other things. To the north-east of Nyassa live the Makangwala, a fierce tribe, much feared by their neighbours. Indeed, some of the tribes living on the borders of the Nyassa have, through dread of the Makangwala, built villages on piles at some distance from the shore. I heard that these Makangwala spoke a kind of Sesuto, and that they, too, come up from the south, and were of Basuto origin, but this I do not state for certain. The only occasion when I saw any was after the Machinga had raised the siege of Mesere's "boma." They were fine feather-plumed, shield-bearing, warriors—much like the Mangoni.

Ubena is a place, the name of which has excited some interest. I believe originally the Wabena lived in Konde, but now they have been driven to the north-east, and inhabit a group of hills by Uranga, near the sources of the River Ranga.

The Wasango speak a language entirely different from the common Nyassa language. At least the resemblance in the commonest terms, such as generally exists in closely related languages, was entirely wanted. I made a long list of words as in Usango, but most unfortunately lost them. I can only remember two at present—a zebra is "sengeri," and a buffalo "kondoli." Some words (such as "mevenda" for cloth, and "maranga" for water) are, I find, also used by the Wa Niamwesi.

Of the Niam Niams I wish I could say more. They had, as I have said, deserted their country, and consequently I saw very little of the people or their habits. It will be remembered that Dr. Schweinfurth met people of this name to the north of the River Welle, in the "heart of Africa." These he describes as cannibals. I found no trace or rumour of this being the case with the Niam Niams of Usango. It is possible that the abundance of cattle may have improved their habits in this respect. But the picutre that Dr. Schweinfurth gives of a Niam Niam village represents them as building round conical huts, whereas here their huts were always square cornered, very strongly built, with flat roofs. The odd form of the name is in itself a proof of the immigration of the Niam Niams to this part. It is, of course, well known that all true African (that is *Bantu*) tribes possess names with the plural affix, generally *Ma*, *Ba*, or *Wa*.

[By the way, I beg to ask philologists whether the only African words that we possess imbedded in the classics, viz., *magalia* and *mapalia*—one, at least, used by Virgil—are not real African plurals?]

With a mere passing allusion to the Wawambara, who from their elaborately twisted locks and their headdresses, as well as from their language, I fancy are a sub-tribe of the Wa Niamwesi, I must bring this paper to a close. I would gladly have said more, if opportunity had served, as to future prospects, but I now think it best to reserve this for a future occasion, and for the present only add

that the two things I most advocate at this moment are—

(1.) Steam launches up the Shire and Nyassa, and a surveyed and beaten route across 150 miles or so to Tanganyika;

(2.) The employment of elephants.

I hope that both these questions may be deemed of sufficient practical interest to provoke some further discussion in the meeting.

At the conclusion of the paper, Dr. Mann said that, in reference to the journey which had been here described in detail, attention should be again drawn to Mr. Hutchinson's excellent sketch-map of proposed routes to Central Africa from the east coast, which appeared in the Society's *Journal* of March 30th, 1877, and to the communication which accompanied that map. The principal routes which were indicated in that communication, it will be remembered, were—the River Dana route from Formosa Bay to Victoria Nyanza; the Zanzibar route to Unyanyembe, with branch lines to Ujijio, Nyangwe, and Cazembe, and towards the unknown region of the Albert Nyanza; the Quiloa, or Kilwa route to the south end of Tanganyika; and the two routes to Lake Nyassa, one by Livingston's track from Cape Delgado along the Rovuma, and the other the usual one up the Zambezi and Shire. Mr. Cotterill's exploration, it will be observed, connects the Quiloa and Zanzibar routes through the high country trending from south to north through the previously untraversed region which lies midway between Lake Tanganyika and the sea. In Mr. Hutchinson's communication made in March last year, there occurs the following passage, which it may be well here to reproduce. He says, in reference to the station at Livingstonia from which this remarkable journey of Mr. Cotterill's was made:—"Let them (our Scotch friends) push up and meet the London Missionary Society from Tanganyika, and make that road a cordon past which no slave gang shall go." It is worthy of memory and note that the gallant explorer, who was the comrade of Mr. Cotterill until he laid down his burthen and went to sleep near the banks of the Kasigo under the baobab tree, after his return from his journey along the coast from Dar-es-Salaam and Quiloa he reported, that upon that expedition alone he had registered as free, 1,408 slaves employed by British subjects.

DISCUSSION.

The Chairman, having spoken of the very graphic way in which the paper had been put before the meeting and the most exhaustive manner in which it dealt with the vast region which it was proposed to enter upon, to civilise, and eventually to colonise, said they were all much indebted to Dr. Mann for the very able introduction with which he had favoured them. He thought that the subject embraced too much to be dealt with adequately upon the present occasion, and, whilst he should be happy to hear any remarks which might be offered, he should also suggest that the paper was one to be discussed in connection with the subject to be brought forward at the next meeting of the Section, when they would have the opinions of practical men, coming from Manchester and elsewhere, whose interests were mostly concerned. All might have their own opinions upon questions of distance and points of detail, such as the best points of departure or points of convergence, or situations for depôts—considerations which would be best discussed when the papers had been printed and circulated, not only amongst the members of the Society, but amongst those interested in the commerce with Africa. He took it that this paper was but a sequence to the one previously read by Mr. Cotterill in May last, entitled "The Nyassa, with Notes on the Slave Trade and Prospects of Commerce and Colonization in that Region." They had not heard much about colonization or about the slave trade that evening, nor was it necessary, since those points had been dealt with in the former paper. Their attention had, however, been drawn to very important features of the country, physical and geographical, its material resources, minerals, and races. Great labour and unceasing perseverance were incidental to everyone who visited Africa, as he could testify, having himself gone through some of its deserts. Toil, and difficulty, and fever were the inseparable accompaniments of such an enterprise, and of course they honoured those who underwent them. Whether they could best approach the Nyassa from the Zambezi or from Zanzibar they could hardly discuss, until they had more opportunity of studying exactly what the distances and difficulties were. Dr Kirk told them, in his report published in 1874, that there was no less than 35,000 slaves taken within about eight miles of the spots mentioned, Malwa, and if there were such a slave trade existing, how were they to get to Nyassa. If any gentleman present had any local information, he should be most happy to hear him, but otherwise he should think it best to adjourn the discussion. In conclusion, he would say that he entirely agreed with the remark made by Mr. Cotterill in his former paper that "never until we establish British influence in the interior shall we strike a death-blow to slavery." The progress now being made on the Gold Coast fully bore out that opinion. Domestic slavery had there been abolished, and most beneficent and humanising results had followed.

Mr. B. F. Cobb said it only remained to return their thanks to Mr. Cotterill for the interesting paper he had given them, and also to Dr. Mann for his scarcely less interesting prelude, in which he had made the meeting *au fait* with all the important points of the journey.

The motion having been carried unanimously,

Dr. Mann said there was another person to be thanked, viz., the gallant Chairman. He was only a bird of passage in England, but he had been kind enough to come amongst them. Having been connected with the West Coast in years gone by, he took so much interest in Africa that he was always willing to assist at the meetings of that Section when he had an opportunity.

The vote of thanks was carried unanimously, and the meeting adjourned.

TENTH ORDINARY MEETING.

Wednesday, February 12th, 1879; Prof. Henry E. Roscoe, F.R.S., F.C.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Beardmore, William, Portishead Forge and Rolling Mills, Glasgow.

Crawley, George Baden, 5, Albany, Piccadilly, W., and Wyvenhoe, Wilbury-road, Brighton, Sussex.

Fairweather, James G., C.E., 12, Buccleuch-place, George-square, Edinburgh.

Greig, John A., 93, Downs-park-road, Lower Clapton, E.

Harborow, Henry Arthur, 4, Circus-street, Marylebone-road, W.

Hooper, John P., The Hut, Mitcham, Surrey.
Horne, Edgar, 10, Woburn-square, W.C.
Howard, William Dillworth, Lordship-lane, Tottenham.
Mackay, Alexander, Trowbridge.
White, John Bazley, 7, Park-square West, Portland-place, W.

The following candidates were balloted for and duly elected members of the Society :—

Armstrong, Mrs. Emily, Dolgelly, North Wales.
Neuhaus, Capt. Mathias, 61, Charlotte-street, Portland-place, W.
Tayler, Frank, 156, Leadenhall-street, E.C.

The Chairman, in introducing Mr. Hollway, said that both scientific and practical men were much indebted to Mr. Hollway for making the experiments he was about to bring forward. His object was to receive help, and to have faults found (if they could be found) in his proposed process, both in its theoretical bearings and practical issues. Mr. Hollway had placed the paper in the hands of all present, and he proposed, therefore, that he should simply give a *résumé* of it, and that then the questions stated at page 262 should be discussed *seriatim*.

The paper read was—

A NEW APPLICATION OF A PROCESS OF RAPID OXIDATION, BY WHICH SULPHIDES ARE UTILISED FOR FUEL.

By John Hollway.

I have the honour to bring before you to-night the result of about twelve months' labour upon a new process for economically treating certain abundant mineral substances, with the object of obtaining from them valuable products. I will briefly state the primary facts upon which the application of this process is based.

The combinations which make up the solid crust of the earth may be said to consist principally of compounds of the elementary bodies with oxygen, and compounds of the elementary bodies with sulphur. Thus we have the element iron mineralised by oxygen, in oxide of iron, occurring in almost all rocks, and forming vast deposits in many parts of the world. Iron is also mineralised by sulphur in sulphide of iron, known as iron pyrites, one of the most abundant natural minerals. Copper, lead, and zinc are likewise found as oxides and sulphides, aud it is from these combinations that the whole of these metals, artificially produced, are extracted. In one or other, then, of these two forms the more common metals occur in nature, and this paper has especial reference to those minerals which contain sulphur. Professor Tennant has kindly lent the specimens of various oxides and sulphides on the table before you.

When metals are extracted from their ores by fusion, the necessary heat is always obtained by the burning of coal, coke, or other form of carbon. I wish, however, to remind you that sulphides can be made to burn in air, and are thus combustible substances, while the oxides are bodies that have been already "burnt," which, as you know, is the conventional expression for entering into combination with oxygen. The metallic sulphides, consequently, are natural combustible minerals, and my object is to prove that they can be utilised as sources of heat in certain metallurgical operations. The most important of the mineral sulphides is pyrites, both on account of the frequency of its occurrence and the extent of its deposits. The predominating constituent in this mineral species is bisulphide of iron, with which are frequently associated sulphides of copper and arsenic; silver and gold are usually present in larger or smaller quantities. When iron pyrites is roasted in the open air, an increase of temperature takes place in its mass, so that the oxidation continues without the application of external heat. This operation is carried on in Spain and other countries, where vast quantities of cupreous pyrites are exposed in heaps for several months to a slow process of combustion, which gradually resolves the sulphide of iron into ferric oxide. A similar combustion is effected in the pyrites burners of the sulphuric acid manufacturers, the solid product of the operation being the so-called "burnt ore," an impure peroxide of iron. The other principal sulphides are those of lead, zinc, and antimony. Sulphuretted ores of copper, lead, and zinc are usually roasted to render them reducible in the furnace, and to make their non-valuable constituents capable of combining with the fluxes used, the requisite heat being always obtained by the combustion of coal or similar material of organic origin. This process of roasting extends over a considerable space of time, and the heat evolved by the oxidation of the sulphides is never very manifest at any period of the operation. The sulphur and metals frequently burn to waste, because the utilisation of the heat resulting from the burning of such fuel has not hitherto been considered a subject of much importance. If, however, a rapid current of air is forced through molten sulphides, the maximum temperature of the combustion is attained, because all the oxygen of the air driven in is then utilised for oxidation, and the operation is concentrated into the space of a few minutes instead of occupying many weeks, or in the case of cupreous pyrites many months.

In the calculations in the latter part of this paper the comparative temperatures produced by the oxidation of the principal sulphides will be found, together with a similar calculation showing the heat obtained during the oxidation of crude iron by Bessemer's process. The data thus obtained indicated to the writer that the oxidation of sulphides would produce sufficient heat to render their smelting a self-supporting operation, and in consequence several experiments were made by forcing a current of oxygen from a gas cylinder into molten sulphide of iron contained in a fire-clay crucible; the tuyères used were porcelain tubes and the stems of common clay pipes. When the current of gas was directed upon the surface of the mass, an intense incandescence with a violet light was observable, showing the high temperature resulting from the oxidation. Upon dipping the tuyère into the sulphide, the temperature visibly increased, and the oxide of iron formed acted energetically upon the silica of the fire-clay; but the contents of the crucible soon became viscous in consequence of the absence of sufficient silica to form a fusible slag.

On the 22nd April, 1878, the experiments were continued, and larger crucibles used; the sulphide of iron was acted upon by a current of air, sand being added during the oxidation. A regulus and

slag were obtained. The sulphide of iron was made by fusing cupreous iron pyrites in a steel melting furnace, the fire of which was allowed to burn down as soon as the oxidation commenced. When the blast of air was turned on, the tuyère was dipped into the contents of the crucible, and the blowing was continued for over 30 minutes. Although the whole of the oxygen was probably consumed, yet the oxidation had not proceeded far enough to concentrate the regulus to any extent. About half the iron was removed as ferrous silicate, in which was found ·104 per cent. of copper, and the separation of the poor regulus from the superincumbent slag was very distinct. It was evident that, to enable the oxidation to take place with sufficient energy, it would be necessary to introduce the air very rapidly, and, after some further experiments, made also with crucibles, which showed that pyrites could be melted by the heat evolved by its own oxidation, a trial was projected with a Bessemer converter, because a rapid transmission of air could be thus obtained, and several experiments were accordingly made during July, 1878.

The plant employed consisted of—

An ordinary cupola, 4 ft. diameter at the tuyères, and higher up 5 ft., having eight tuyères, four being 3 in. in diameter, and the remaining four 4 in. in diameter.

A ladle for conveying the molten metal to the Bessemer converter.

A Bessemer converter, capable of treating 6 tons of crude iron at a time, lined, as usual, with gannister, and supplied with cold blast.

The engines for supplying the blast were two cylinders of 42 in. diameter, and 4 ft. stroke, working at about 45 revolutions per minute, at an average pressure of steam in the boilers of 73 lbs. per square inch.

The pyrites was put into the cupola with coke and treated like pig iron. When at each operation the cupola was tapped, the molten protosulphide was run into a ladle and thence into the converter.

In the first of these experiments, which took place 10th and 11th July, 1878, about five tons of molten sulphides were blown for half an hour in the same manner as a charge of Bessemer iron. After thirty minutes' blow, the contents, consisting of silicate of iron and regulus, were turned out of the vessel. No sand had been thrown into the converter, therefore the gannister lining was energetically attacked by the oxide of iron. The product was very liquid when run from the vessel, the slag crystallising on cooling in splendid crystals of ferrous orthosilicate.

In the next experiment, made on 11th and 12th July, 1878, protosulphides containing 3·4 per cent. of copper yielded, after a quarter of an hour's blow, a regulus containing 46 per cent. of copper, and the destructive action upon the gannister lining was greatly mitigated by throwing sand into the converter.

Six experiments were made on the 17th and 18th of July, 1878. The pyrites used contained 2 to 3 per cent. of copper, 1·5 oz. of silver and 3 grains of gold per ton. Owing to the small quantity of protosulphide employed at each of these experiments, the blowing had to be of very short duration, and great care was also necessary to avoid overblowing. To obviate this the blowing had to be arrested earlier than would be necessary to produce a regulus containing the desired per-centage of copper; but in operating with larger quantities of protosulphide, there would not be the same difficulty.

The spectroscopic phenomena were observed through a six-prism spectroscope. The six experiments were all arranged, and the duration of each blow in the Bessemer previously settled; and the first, second, and third experiments were so carried out; the fourth was intentionally overblown, in order to observe the changes in the spectrum, and the result of these observations was that in the fifth and sixth experiments the blow was arrested at the moment indicated by the disappearance of certain lines in the spectrum.

The increments in the temperatures of the gases at the mouth of the converter were measured by means of one of Siemens' differential pyrometers. The pyrometer was 8 ft. in length, with platinum leading wires from the platinum spiral to the terminals. The end exposed to the gases was protected for 1 ft. 6 in. of its length by a porcelain tube 2 ft. long, and the next 2 ft. by loam placed around the iron tube of the pyrometer. The indicated temperature was always below that actually obtained, as the fire-clay coating protecting the exposed stem of the pyrometer retarded the transmission of heat.

The gases were sampled by means of a fire-clay bell, connected with half-inch iron tubing, protected by clay from the hot sulphur vapour. The iron tube, at a distance of about 20 ft. from the converter, had inserted in it two pieces of brass pipe, to which were connected, by india-rubber tubing, two glass tubes for taking the gases. The free ends of the gas tubes were connected through a T piece with a powerful aspirator holding 20 gallons of of water. By turning a tap and shutting off the water-cock of the aspirator, both tubes could be filled with identical samples of gas evolved from the converter at any given moment. The sublimate appeared in the glass tubes about three seconds after turning the taps. To avoid any interruption in the experiments, two converters were fitted with similar appliances, both pyrometers being connected with the same instrument, but only one converter was used.

In the first experiment, on the 17th July, 1878, the blow occupied 17 minutes, during which period 14 cwt. of red sand were added. The amount of protosulphide introduced into the vessel could not be exactly ascertained. The mean pressure of blast was 20 lbs. per square inch. The phenomena at the mouth of the converter were very remarkable. At the commencement dense white fumes issued from the mouth of the converter, coloured in varying tints by the volatilisable metals present in the incandescent state, which afforded a very brilliant spectrum containing a great number of bright lines. When the temperature rose and the lead was in great part expelled, the flame showed less "body" and was of a bluish-green colour, possibly from the presence of minute quantities of zinc and copper. The blown product of the experiment was emptied into ingot moulds and allowed to cool. When cold it was found to consist of three zones, the upper one being the slag proper, the central zone a mixed product of slag and regulus, and the lowest a regulus free from silica. The specific gravity of the regulus was about 4·8, and the slag about 4·1.

The products of the experiments gave upon analysis the following results:—

Protosulphide sampled as it ran from Cupola.

	Per Cent.
Iron	59·62
Copper	3·52
Zinc	1·52
Lead	0·79
Arsenic	0·06
Manganese	0·21
Alumina	0·15
Lime	0·28
Magnesia	0·27
Sulphur	33·10
Silica	0·15
	99·67

Slag.

	Per Cent.
Protoxide of iron	53·30
Peroxide of iron	3·00
Iron combined with sulphur	5·79
Copper combined with sulphur	0·16
Lead	0·12
Zinc oxide	1·15
Arsenic	trace.
Manganese oxide	0·32
Alumina	2·15
Lime	0·40
Magnesia	0·46
Sulphur	3·39
Silica	29·90
	100·14

Mixed Regulus and Slag.

	Per Cent.
Iron	55·00
Copper	5·00
Sulphur	10·41
Silica	12·70
	83·11

Regulus.

	Per Cent.
Iron	57.10
Copper	15·85
Zinc	0·84
Lead	0·22
Arsenic	0·04
Manganese	0·22
Alumina	0·11
Lime	0·34
Magnesia	0·34
Sulphur	21·96
Silica	2·00
Oxygen and loss	0·98
	100·00

By cupellation this regulus was found to contain:—

	Oz.	Dwt.	Gr.
Silver per ton	10	16	10
Gold ,,	·0	6	12

Another sample of the regulus taken gave in three cupellations:—

	Per Ton. oz.	dwt.	gr.	Per Ton. oz.	dwt.	gr.	Per Ton. oz.	dwt.	gr.
Silver	9	0	22	8	17	6	8	19	7
Gold	0	1	23	0	1	23	0	1	23

The variations of the temperatures of the gases at the mouth of the Bessemer converter, as measured by Siemens' differential pyrometer, were as follows:—

		Centigrade.	
July 18, 1878.—	12.19 a.m.	68°	
,,	12.20 a.m.	157°	+ 89°
,,	12.22 a.m.	169°	+ 12°
,,	12.23 a.m.	219°	+ 50°
,,	12.24 a.m.	232°	+ 13°
,,	12.26 a.m.	292°	+ 60°
,,	12.28 a.m.	401°	+109°
,,	12.29 a.m.	527°	+126°
,,	12.31 a.m.	648°	+121°
,,	12.32 a.m.	686°	+ 38°
,,	12.34 a.m.	703°	+ 17°

The second experiment was very similar to the first, but about 30 cwts. of fused protosulphide were used. The sand added was about 14 cwt., which was thrown in, as in the first experiment, by men standing near the mouth of the converter. The pressure of blast was 20 lbs. This blow lasted 18 minutes. The products were very similar in composition to those obtained in the first experiment, and there was, as before, an intermediate matt. The slag was dense, black, and very crystalline; it showed a peculiar radiated structure at the edge near the iron moulds caused by the sudden chill.

The zones were not horizontal, but were more or less conical, as owing to the sudden refrigeration of the mass the denser particles had subsided last in the central portion which remained fluid longest.

The analyses of the slag and regulus obtained are as follows:—

Protosulphide sampled as it ran from Cupola.

	Per Cent.
Iron	60·30
Copper	3·25
Zinc	1·88
Lead	0·81
Arsenic	0·05
Manganese	0·20
Alumina	trace
Lime	0·34
Magnesia	0·32
Sulphur	32·50
Silica	0·30
	99·95

Slag.

	Per Cent.
Protoxide of iron	54·62
Peroxide of iron	3·71
Iron combined with sulphur	4·27
Copper combined with sulphur	0·22
Lead	0·10
Zinc oxide	1·75
Arsenic	trace
Manganese oxide	0·37
Alumina	2·06
Lime	0·37
Magnesia	0·45
Sulphur	2·55
Silica	30·05
	100·52

Mixed Regulus and Slag.

	Per Cent.
Iron	58·50
Copper	5·32
Sulphur	16·47
Silica	6·80
	87·09

Regulus.

	Per Cent.
Iron	56·05
Copper	16·59
Zinc	0·48
Lead	0·31
Arsenic	0·03
Manganese	0·20
Alumina	0·13
Lime	0·16
Magnesia	0·25
Sulphur	23·47
Silica	1·10
Oxygen and loss	1·23
	100·00

By cupellation the regulus or matt was found to contain:—

	Per Ton. oz.	dwt.	gr.
Silver	11	15	10
Gold	0	7	0

Another sample of regulus gave in three cupellations:—

	Per Ton of Regulus. oz.	dwt.	gr.		oz.	dwt.	gr.		oz.	dwt.	gr.
Silver	12	1	17	..	11	15	4	..	11	18	10
Gold	0	6	12	..	0	6	12	..	0	6	12

The variations in temperatures of the gases at mouth of the converter, as measured, were as follows:—

		Centigrade.	
July 18, 1878.—	2.11 a.m.	60°	
,,	2.13 a.m.	85°	+ 25°
,,	2.14 a.m.	97°	+ 12°
,,	2.15 a.m.	168°	+ 71°
,,	2.17 a.m.	205°	+ 37°
,,	2.18 a.m.	262°	+ 57°
,,	2.19 a.m.	340°	+ 78°
,,	2.21 a.m.	412°	+ 72°
,,	2.22 a.m.	518°	+106°
,,	2.24 a.m.	558°	+ 40°
,,	2.25 a.m.	600°	+ 51°
,,	2.27 a.m.	690°	+ 81°

In the third experiment the charge was more fully blown. The protosulphide used was about 25 cwt. and the sand added about 14 cwt. The blast pressure was 20 lbs. per square inch, and the blow occupied 17 minutes, which was somewhat too long. The separation of the slag from the rich regulus immediately beneath it was very distinct.

The analyses of products in this experiment are as follows:—

Regulus.

	Per Cent.
Sulphur	22·22
Iron	12·56
Copper	62·36
Zinc	0·42
Lead	0·14
Insoluble matter	0·28
Oxygen, and not estimated	2·02
	100·00

Average of the Slag.

	Per Cent.
Metallic iron	49·30
,, copper	1·55
Oxide of zinc	0·98
Manganese protoxide	0·30
Arsenic	None.
Lime	0·63
Alumina	1·08
Silica	29·55
Sulphur	6·67
Magnesia, oxygen, and not estimated	9·94
	100·00

The pyrometrical variations were as follows:—

		Centigrade.	
July 18, 1878.—	3.58 a.m.	60°	
,,	4. 0 a.m.	86°	+ 26°
,,	4. 1 a.m.	121°	+ 35°
,,	4. 2 a.m.	177°	+ 56°
,,	4. 3 a.m.	219°	+ 42°
,,	4. 5 a.m.	296°	+ 77°
,,	4. 6 a.m.	346°	+ 50°
,,	4. 7 a.m.	422°	+ 76°
,,	4. 9 a.m.	479°	+ 57°
,,	4.10 a.m.	550°	+ 71°
,,	4.12 a.m.	726°	+176°

In the fourth experiment the charge was over blown by about six minutes. No sand was added in this blow; about 1 to $1\frac{1}{4}$ tons of fused protosulphide were used. The product was apparently homogeneous in composition, and gave on analysis:—

	Per Cent.	
Silica	34·34	
Iron protoxide	25·10	= 43·27 per cent. metallic iron.
Iron peroxide	33·83	
Manganese protoxide	0·12	
Alumina	1·81	
Zinc oxide	0·73	
Copper oxide	2·39	= 1·91 per cent. copper.
Lead oxide	0·03	
Lime	0·24	
Magnesia	0·30	
Sulphur	0·15	
Arsenic	None.	
Phosphoric acid	0·031	
Not estimated	1·45	
	100·521	

This slag is less basic and far less crystalline than those ordinarily produced, and the copper exists principally as oxide. As soon as the subsulphide of copper began to burn, a splendid emerald-green flame suddenly appeared, lasting about a minute, and all the lines except those of copper and sodium left the spectrum. During the last few minutes of the blow the mouth of the converter was dull and without flame. The sublimate taken from the tuyère bell by which the gases were collected contained, however, but little copper, which may be seen by the following analysis:—

	Per Cent.	
Sulphate of lead	52·08	= 50·91 per cent. of metallic lead.
Sulphide of lead	17·29	
Zinc oxide	21·78	= 17·47 per cent. of metallic zinc.
Copper oxide	0·09	= 0·07 per cent. of metallic copper.
Iron sesquioxide	2·86	
Insoluble residue	2·14	
Not estimated and loss	3·76	
	100·00	

The small quantity of copper found in the sublimate shows the delicacy of the flame test. The lead appears to have distilled as sulphide, and after condensation to have become oxidised on the tuyère bell by the blast of hot air, which had not

been entirely deprived of its oxygen during the last six minutes of the blow.

The pyrometer indicated the following variations of temperature, viz.:—

		Centigrade.	
July 18, 1878.—	5.28 a.m.	97°	
,,	5.29 a.m.	136°	+ 39°
,,	5.31 a.m.	193°	+ 57°
,,	5.32 a.m.	311°	+ 118°
,,	5.33 a.m.	348°	+ 37°
,,	5.35 a.m.	559°	+ 211°
,,	5.37 a.m.	643°	+ 84°
,,	5.39 a.m.	694°	+ 51°
,,	5.41 a.m.	765°	+ 71°
,,	5.42 a.m.	796°	+ 31°
,,	5.44 a.m.	802°	+ 6°

In the fifth experiment were used about 1 ton of protosulphide and 12 cwt. of of sand. Pressure of blast, $17\frac{1}{2}$ lbs. Length of blow, 12 minutes. The regulus produced contained:—

	Per Cent.
Copper	63·43
Iron	13·20
Sulphur	20·37
Insoluble matter	1·20
Zinc silver, and not estimated	1·80
	100·00

Per Ton of Regulus.

	oz.	dwt.	gr.	oz.	dwt.	gr.	oz.	dwt.	gr.
Silver	54	11	1	53	11	11	54	1	6
Gold	0	19	14	1	2	20	1	1	5

This regulus was found to contain ·12 metallic copper, which gave on testing for silver and gold:—

	Per Ton of Copper. oz.	dwt.	gr.
Silver	201	4	12
Gold (only traces at the most)	0	2	0

The rest of the ingots consisted of a mixed regulus and slag, the lower part being a basic silicate of protoxide of iron with regulus entangled therein in minute veins throughout the mass, the upper part containing less entangled regulus than the lower part. The products in this experiment were more heterogeneous, on account of the residual slag left in the converter from the fourth experiment.

The lower part contained:—

	Per Cent.
Iron	58·06
Copper	2·34
Lime	trace
Siliceous matter, containing a little oxide of iron	15·33
Sulphur	9·79
Lead, zinc, and not estimated	14·48
	100·00

The upper part contained:—

	Per Cent.
*Iron protoxide	67·17
Copper	0·87
Sulphur	1·08
Lime	0·07
Silicious matter	28·53
Zinc, lead, alumina, and not estimated	2·28
	100·00

* For convenience the iron is stated as protoxide, although a small quantity existed as sulphide, and there was also some peroxide present.

The variations of the temperatures of the gases at the mouth of the converter were as follows:—

		Centigrade.	
July 18, 1878.—	6.29 a.m.	151°	
,,	6.30 a.m.	183°	+ 32°
,,	6.31 a.m.	298°	+ 115°
,,	6.33 a.m.	367°	+ 69°
,,	6.34 a.m.	542°	+ 175°
,,	6.36 a.m.	599°	+ 57°
,,	6.38 a.m.	665°	+ 66°
,,	6.39 a.m.	734°	+ 69°

The sixth and last experiment of this series was made upon about 20 cwt. of the fused protosulphide; about 11 cwt. of sand were thrown in with a shovel during the blow, which lasted 11 minutes. A central zone of mixed regulus and slag was obtained as in the first experiments of the series, and its composition was somewhat similar. It is of interest to observe that this contained neither silver nor gold, which were concentrated in the rich well-separated bottom regulus.

Slag.

	Per Cent.
Copper	0·42
Protoxide of iron	67·52
Silica	26·22
Alumina	2·46
Sulphur	2·06
Oxygen and loss	1·32
	100·00

Mixed Regulus and Slag.

	Per Cent.
Copper	5·20
Protoxide of iron	70·42
Sulphur	4·17
Alumina	1·57
Silica	14·67
Oxygen and loss	3·97
	100·00

By cupellation this regulus gave neither gold nor silver.

Regulus.

	Per Cent.	
Copper combined with sulphur	59·71	
Metallic copper	0·27	
		59·98
Iron		13·16
Sulphur		21·94
Insoluble residue consisting of sand and oxide of iron		2·57
Silver and gold		0·152
Oxygen and loss		2·198
		100·000

In three cupellations, the regulus or matt was found to contain, per ton of 20 cwt.:—

	oz.	dwt.	gr.	oz.	dwt.	gr.	oz.	dwt.	gr.
Silver	48	6	22	48	3	15	48	5	6
Gold	1	6	3	1	2	10	1	4	11

During the preliminary melting of the pyrites in the cupola, the flame seen at the charging-door of the cupola exhibited brilliant colours, continually changing in tint. This flame brightly illuminated the visible spectrum. The greater part of the lead was volatilised during this preliminary melting. Indications were, besides, obtained of the volatilisation of sodium, lithium, and thallium. The flame of sulphur and that of carbonic oxide give no distinctive lines, neither does arsenic volatilised

as arsenic trioxide; hence no indication of the presence of these substances was to be expected, and zinc was probably not present in this flame in the form of vapour. The spectrum flame from the Bessemer converter during the "blow" was a very brilliant one. The lines of sodium, lithium, and thallium were recognisable, but the majority of the lines are of (as yet) unknown origin, though they are the most important, since the changes furnish indications of the progress of the chemical changes taking place in the vessel. Some of these unknown lines are those which were employed as "test lines." No lines of lead were observed, nor of copper, except in the fourth experiment, in which all the lines, except those of sodium, disappeared about six minutes before the "turn down." The charge took longer to melt in the cupola than a corresponding weight of pig iron under the same circumstances, but, when once molten, the protosulphides formed a mobile limpid liquid.

Whenever during the experiments the converter was tipped forward the sulphurous acid poured out into the pit and made itself apparent by its strong odour. When the converter was in position, however, and the blast on, the smell was scarcely perceptible in the close vicinity of the flame, in consequence, doubtless, of the rapid convection of the hot gas. The lining of the converter after the six blows was found to be not very materially acted upon, and therefore the reserve converter was not required.

The products of the experiments which remained for examination consisted only of slag and regulus and a few samples of the gases evolved. The sulphur and sublimates were principally lost in the cupola, which, as before-mentioned, was only used for convenience. In practice, the volatilised substances would be collected in flues.

Further experiments were made on the 1st and 2nd of November, 1878, also with a Bessemer converter. To start the oxidation, about two tons of fused protosulphides were run into the vessel, which was then brought into position and the charge was blown for about five minutes without any addition. As the heat of mass increased, four tons of cold pyrites were thrown into the converter gradually, in large lumps, together with 9 cwt. of sand containing over 16 per cent. of moisture. Although a large quantity of heat was expanded in expelling the sulphur from the cold pyrites, and in the expulsion of the water from the sand, yet the contents of the converter were maintained perfectly liquid by the heat of oxidation. After blowing some time, half the charge was tipped into the ladle, and, after the converter had been again placed in position, 18 cwt. more pyrites were added, in lumps, and 3 cwt. more sand. After a short time the blowing was discontinued and the contents were run out into the ladle.

During the experiment sulphur vapour burned at the mouth of the converter and phenomena were observed similar to those previously cited. It was proved to those present that the smelting of pyrites can be made a self-supporting operation, and that copper regulus, silicate of iron slag, volatile sublimates, and sulphurous acid can be obtained without the employment of any extraneous fuel other than that employed in producing the blast.

Another experiment of a similar nature had been previously attempted, but the addition of cold and wet raw material too early in the operation caused too great a reduction in the temperature, and the chilled contents of the converter had to be extracted by melting with coal. This refrigeration will be readily understood when the heat rendered latent by the fusion of the bisulphide of iron is taken into account, besides which large quantities of gas left the liquid mass at a red heat, and were not utilised to heat or to drive off sulphur from the raw material.

These experiments were carried out with ordinary Bessemer plant, but, for many reasons a Bessemer converter is not suitable for the reduction of cold pyrites to regulus, nor has it any arrangements for allowing the regulus to accumulate out of the reach of the blast. Upon running the molten mass from the ladle into one of the ingot moulds, the slag ran in a thick cylindrical stream of perfect continuity, falling without noise a distance of some feet into the liquid portion below. This lasted five minutes, and resembled the effect produced by illuminating a continuous column of liquid by a ray of light passed along its axis.

The products of these experiments were found to be partly overblown. It appears that on pouring out a portion of the contents of the vessel the principal part of the regulus ran out before the slag, which was then reblown. This burned the sulphur out of the latter and peroxidised some of the iron, the heat derived from the oxidation of the iron protoxide into peroxide being sufficient to keep the whole liquid.

The underblown regulus contained 8·4 per cent. of copper, and the overblown slag 2·36 per cent. of copper and ·25 per cent. of sulphur, which is insufficient to allow the copper to exist as subsulphide.

Very fine specimens of silicate of iron were obtained in the last experiment crystallised in large thin plates, sometimes nearly an inch in diameter, or in superposed arrow-headed masses, frequently striated with lines parallel to the plane angles. These crystals approximate in composition to orthosilicate of iron 2 Fe O. SiO_2, and the average result of the analyses of the slags corresponds to such a composition. Thus the slag produced in the July experiments contained in five samples:—

Silica.

		Per Cent.
Experiment	1	29·90
,,	2	30·05
,,	3	29·55
,,	5	28·53
,,	6	26·22

Or a mean of 28·85 per cent. of silica, while ferrous orthosilicate contains 29·4 per cent., the difference being accounted for by the presence of entangled regulus. The affinity of the basic silicate for silica seems to suddenly decrease as soon as this limit of saturation is attained. A peculiar slag was obtained in one experiment, having a metallic appearance. It was not crystallised in plates, but apparently in confused prisms. It corresponds in formula to a sulphosilicate of iron agreeing in composition with the formula 13 Fe O, Fe S, 7 SiO_2, or orthosilicate of iron, in which one atom of Fe O in fourteen has been replaced by Fe S. Neglecting small quantities of copper and alumina present, the crystals gave on analysis :—

	Found. Per Cent.	Calculated for $13\,Fe\,O, Fe\,S, 7\,Si\,O_2$ Per Cent.
Iron Protosulphide	6·10	6·09
Silica	28·99	29·08
Iron Protoxide, with Mn O and Zn O=2·78 per cent.	64·12	64·82
	99·21	99·99

This compound seems to be, therefore, a sulpho-silicate of iron, but it differs in constitution from Helvin (the only mineral in which sulphur and silica are found in combination) by having two atoms of metal to one of silica, whereas the latter contains seven of metal to three of silica. Two determinations of its specific gravity gave 4·19 and 4·22.

The specific gravities of the slags formed in the experiments did not greatly vary, and the following table gives those of the slag and regulus in the products of the earlier experiments at Penistone:—

Regulus.

Experiment	1	4·73
,,	2	4·80
,,	3	5·12
,,	5	5·18
,,	6	4·95

Slag.

Experiment	1	4·08
,,	2	4·10
,,	3	4·02
,,	4	3·57
,,	5	4·20
,,	6	4·17

The regulus given is the bottom regulus. The average specific gravity of the slag (omitting No. 4) is 4·11, and that of the regulus is 4·96. The high density of the slag does not permit of the ready subsidence of the suspended regulus, and tends to cause its entanglement.

The regulus usually contained a considerable excess of iron above that necessary to form protosulphide, assuming the copper to be combined as subsulphide. In the first two samples of regulus, of which the analyses are given, this excess amounts to 25·6 per cent. and 22·3 per cent. respectively. Upon solution of the regulus in sulphuric acid this iron evolves hydrogen, while that combined with sulphur gives rise to sulphuretted hydrogen; sulphide of copper is left insoluble and flocculent by this reaction. It is evident that the iron that thus gives hydrogen by decomposing acids would act as a powerful reducing agent upon oxide of copper, if present in the slag, becoming itself protoxide and precipitating metallic copper. Probably this decomposition gives rise to moss copper in copper regulus. During the middle and end of the blow this iron si oxidised more rapidly than the iron protosulphide, being the more combustible of the two.

The gases evolved from the converter consisted principally of sulphurous acid and nitrogen. The high temperature at which they left the vessel has been already referred to; they carried with them sulphur vapour, which burned with a blue flame at the converter mouth. Pieces of wrought iron placed in this stream of incandescent sulphur were rapidly melted, although the actual temperature was not high enough to melt cast iron. It is peculiar that this occurred with protosulphide (from the cupola); and from certain observations, which will be referred to on a future occasion, it seems evident that the compound Fe S lost some of its sulphur in the free state. From certain considerations it appears that, under the conditions cited, iron is more oxidisable than the sulphur with which it is combined, and burns first in presence of a limited amount of oxygen.

The iron in the slag is found in the form of protoxide, therefore the following is the principal decomposition which takes place:—

$$Fe\,S + O_3 = SO_2 + Fe\,O.$$

Oxygen being mixed with nitrogen in air, in the proportion of 20·8 to 79·2, it follows that 14·4 volumes of air introduced give two volumes of sulphurous acid and 11·4 of nitrogen; the gases evolved in this process thus contain about 14·9 per cent of sulphurous acid.

Contrasting the foregoing with the ordinary process of burning pyrites for the production of sulphuric acid, we have in the latter the following reaction:—

$$2\,Fe\,S_2 + O_{11} = Fe_2\,O_3 + 4\,SO_2$$

or, 52·9 volumes of air introduced, give 41·9 volumes of nitrogen, and 8 of sulphurous acid; the gases evolved by the ordinary process thus contain about 16 per cent. of sulphurous acid as compared with 14·9 per cent. by the new process.

In the fifth experiment, only about 25 cwt. of pyrites were used; there was, therefore, only a very shallow layer of protosulphide over the tuyères of the Bessemer. Two samples of gases were taken, one at six minutes and another at twelve minutes from the commencement of the blow, the latter just as the converter was turned down. Tube No. 58 at 6.33 a.m.; tube No. 35 at 6.39 a.m.

The analyses made by Professor Frankland, F.R.S., gave the following results:—

Tube, No. 58.

	Per Cent.
Nitrogen	86·00
Sulphurous acid	14·00
Carbonic acid	0·00
Carbonic oxide	0·00
Oxygen	0·00
	100·000

Tube, No. 35.

	Per Cent.
Nitrogen	88·37
Sulphurous acid	10·88
Carbonic acid	0·00
Carbonic oxide	0·00
Oxygen	0·75
	100·00

From the above analyses it will be seen that no carbon was taken up by the sulphides in the cupola. Tube No. 35 was taken a second or so after the converter was turned away from the tuyère bell, and thus a little air (0·75 oxygen = 3·7 air) was probably drawn over by the aspirator from the surrounding atmosphere. Eliminating the air makes the analyses as follows:—

	Per Cent.	
Nitrogen	88·7	100.
Sulphurous acid	11·3	

The analysis of the sublimate taken after experiment 4 from the tuyère bell has been already given, from which it will be seen that the substances volatilised from the converter in these experiments consisted essentially of sulphide of lead and zinc oxide, and as a powerful aspirator was used to draw over the gases, a considerable amount of these passed with the gases into the tubes.

Unfortunately, these volatilised substances sometimes blocked up the narrow connections used in fitting the gas tubes, and the bell which collected the gases at the mouth of the Bessemer was also occasionally stopped by projected matter from the converter. These occurrences caused many of the tubes taken to partially fill with air, and they are thus valueless.

Further experiments with Bessemer plant were made on 5th February last, at which Prof. Roscoe and other friends were present. The first experiment was accidentally overblown, besides being chilled by the addition of more than the calculated quantity of sandstone. In attempting to continue the operation by the addition of lumps of pyrites, the strong current of air traversing the silicate of iron refrigerated it, and caused the mass to set in the vessel. It was partly extracted by the aid of coal, and partly by means of rods. About two hundred-weight of coal were now thrown into the empty vessel, and lumps of cold pyrites were added. The blowing being resumed, liquid protosulphides accumulated on the tuyère hearth of the vessel, and pyrites and sand were continuously introduced during eight hours. While the operation was in progress a steam-pipe burst, and the blowing was discontinued for twenty minutes. The contents of the vessel, however, remained fused, and the operation was continued without any difficulty. During the eight hours the blow lasted, a continuous jet of sulphur vapour burned at the mouth of the converter, where it came in contact with the external air. Round the edges, particularly at the base, the flame was of the well-known blue colour of burning sulphur; but the body of the flame appeared of a greenish tint. This was due to the yellowish brown colour of the unburnt incandescent vapour of sulphur and the blue colour of the sulphur flame; viewed through a small direct vision spectroscope, many absorption bands were seen occurring at apparently regular intervals from the red to the violet. Dr. Watts believes the spectrum to be principally due to sulphur. Over eight tons of sulphur vapour were probably burnt in the eight hours, and about 18 tons of raw pyrites were treated.

Iron pyrites, $Fe\,S_2$ upon fusion, yields about one equivalent of free sulphur in the state of vapour, and becomes protosulphide of iron, which rapidly absorbs oxygen when exposed to the action of air, the iron becoming protoxide. When air is forced through the liquid sulphide, a very energetic reaction takes place, and the protosulphide becomes converted into protoxide in a very short space of time. The reaction representing this decomposition is $Fe\,S + O_3 = Fe\,O + S\,O_2$, but the nitrogen of the air is not expressed in the equation, although it serves to reduce the resultant thermal effect. The actual amount of heat evolved by the foregoing decomposition cannot be exactly calculated, because the specific heat of the gaseous products varies with their temperature. But a rough comparative estimate of the mean temperature of the operation may be arrived at. To obtain approximately the absolute number of heat units represented by the combustion, we add together the heat units resulting from the oxidation of the sulphur and the iron, and subtract the heat necessary to dissociate the iron from the sulphur. In the absence of more reliable information upon the heat absorbed in the dissociation of the elements, we assume that it is equal to the amount generated by their combination. The aqueous vapour in the air is neglected in these calculations:—

For Sulphur.—One gram gives on burning in oxygen 2220 gram water units (Favre and Silbermann) Fe S contains 36·36 per cent. S. Therefore ·3636 S × 2220 gram water units =	807·2
For Iron.—One gram of oxygen evolves in combining with its equivalent of iron 4478 gram water units (Favre and Silbermann). To burn ·6364 grams of iron to protoxide ·1818 oxygen is required. Therefore ·1818 O × 4478 gram water units =	814·1
	1621·3
Deduct heat absorbed by dissociation of Fe S. According to Favre and Silbermann, one gram of Fe combining to form Fe S evolves 634 gram water units. Therefore ·6364 × 634 gram water units =	403·4
Gram water units	1217·9

Dividing 1217·9 gram water units by the specific heat of the products and of the nitrogen associated with the oxygen used, we have—

·727 SO_2 × ·154 specific heat of sulphurous acid = ...	·1119
1·326 N. × ·244 specific heat of nitrogen =	·3235
·8181 Fe O × ·137 specific heat of iron protoxide = ...	·1121
Total Sp. Heats	·5475

$\frac{1217 \cdot 9}{\cdot 5475} = 2225°$ Centigrade, or the temperature produced by the combustion of protosulphide of iron.

The above calculation assumes, as all such calculations must assume, that the chemical affinities exercise the same force at the temperature of the operation as in the experiments where the data were obtained, and also that this affinity is not diverted by dissociation.

With zinc sulphide the reaction is—

$$Zn\,S + 3\,O = Zn\,O + SO_2.$$

Taking, as before, 1 as a unit, and calculating in the same way:—

	Heat Units.
Heat of combustion of zinc = 1300 (Andrews' Dulong)—Therefore ·67 × 1300 heat units = ...	871
Heat of combustion of sulphur = 2220 heat units (Favre and Silbermann). Therefore ·33 × 2220 heat units =	732·6
	1603·6
Deduct heat units absorbed in dissociation of Zn S =	431·5
Gram water units	1172·1

Specific Heats.

·66 SO_2 × ·154 = ...	·1016
1·585 N. × ·244 = ...	·3867
·835 Zn O × ·12 = ...	·1002
	·5885

$\frac{1172\cdot1}{\cdot5885}$ = 1992° C., or the temperature produced by the combustion of sulphide of zinc.

With sulphide of lead a similar oxidation is assumed—

$$Pb\,S + 3O = Pb\,O + SO_2$$

·866 × 266 (Calor. Equiv. Pb.) = ...	230·4
·134 × 2220 (Calor. Equiv. S.) = ...	297·5
	527·9
Less dissociation of Pb and S ·866 × 91·9 =	79·6
	448·3

Specific Heats.

·268 So_2 × ·154 = ...	·0413
·646 N. × ·244 = ...	·1576
·933 Pb O × ·0447 = ...	·0417
	·2406

$\frac{448\cdot3}{\cdot2406}$ = 1863° C., or the temperature produced by the combustion of sulphide of lead.

In comparison with these figures, showing the temperature of oxidation of sulphides, we give a similar calculation on coal, also using air, in which it is assumed that the coal contains 80 per cent. carbon, 5 per cent. hydrogen, and 15 per cent. of non-combustible matter of specific heat ·2.

·8 × 8080 (Favre and Silbermann) =	6464
·05 × 34462 ,, ,, =	1723
	8187
Less dissociation of C + H, say	187
	8000

Specific Heats.

2·933 CO_2 × ·216 Sp. H. = ...	·633
8·161 N × ·244 Sp. H. = ...	1·991
·450 H_2 O × ·48 Sp. H. = ...	·216
·15 × ·2 = ...	·030
	2·87

$\frac{8000}{2\cdot87}$ = 2787° C., or the temperature produced by the combustion of coal.

In this latter case it will be seen that the high specific heat of the products decreases the temperature, instead of exalting it beyond the initial heat product.

The following is a calculation made on the Bessemer process, assuming that the crude iron was introduced into the Bessemer at 1650° Centigrade, and contained 4·2 per cent. C and 2·8 Si, also that the carbon, silicon, as well as 7 per cent. of the iron were oxidised in the operation:—

1· Crude Iron × ·114 Sp. Heat of Fe × 1650° C	Temperature at which the Iron is introduced into the Bessemer.	= 188·1
·042 C burning with ·056 O = ·098 C O *i.e.*,	·042 C × 5366 Calorific value of C + O	= 225·37
·028 Si ,, ·032 O = ·06 Si O_2 *i.e.*,	$\frac{\cdot032\text{ O} \times 6216\text{ Calorific value of 1 litre of O}}{\text{1 Litre of O weighs 1·4298 grs.}}$	= 139·1
·07 Fe ,, ·03 O = ·1 Fe_2 O_3 *i.e.*,	$\frac{\cdot03\text{ O} \times 6216\text{ Calorific value of 1 litre of O}}{\text{1 Litre of O weighs 1·4298 grs.}}$	= 130·4
·379 N × ·244 Sp. Heat of N × 50° C	Temperature at which the air is blown in................	= 4·62
·118 O × ·24 ,, O × 50° C	,, ,, ,, ,, ...	= 1·41
		689·00

·042 C	+ ·056 O = ·098	C O	× ·245 Sp. Heat of C O	=	·0240
·028 Si	+ ·032 O = ·06	Si O_2	× ·32 ,, Si O_2	=	·0192
·07 Fe	+ ·03 O = ·1	Fe_2 O_3	× ·17 ,, Fe_2 O_3....................	=	·017
Nitrogen	·379	N	× ·244 ,, N	=	·09247
·86 Fe	·86	Fe	× ·114 ,, Fe........................	=	·09804
1· Crude Iron	1·712	*i.e.*,	1·Fe + ·594 N + ·118 O		·25072

$\frac{689\cdot00}{\cdot25072}$ = 2748° Centigrade.

The foregoing calculations serve to demonstrate what a large amount of heat is stored up in the mineral kingdom in other forms than those derived from organic nature. The largest deposits of coal existing in various parts of the world are, perhaps, more than rivalled as sources of latent heat by the natural sulphides, abundant in every country, occurring in almost every vein, and which constitute, in fact, a material portion of the earth's crust.

In practice fluxes are present during the reaction, Fe S + 3 O = Fe O + SO_2; because the protoxide of iron requires silica to form slag, and these fluxes can be introduced with the charge of pyrites. Such poor metalliferous substances as the gangue of mines, ancient scoriæ, poor siliceous copper ores, &c., containing small quantities of valuable metals, may thus be advantageously utilised, and the copper, lead, and silver they contain will be found in the regulus or sublimates. These materials can be introduced in considerable quantities, because their specific heat is low.

The following is a calculation of the quantities of constituents of a working charge when burning pyrites with a cold blast of air. It is assumed that the pyrites contains 90 per cent. Fe S_2, *i.e.*, 48 per cent. S, 42 per cent. Fe, and 10 per cent. foreign matter. The following are the principal reactions, neglecting the formation of slag:—

$$5\,Fe\,S_2 + 12\,O = Fe\,S + 4\,Fe\,O + 4\,S\,O_2 + 5\,S.$$

$\cdot48\ S \times \frac{4}{10} = \cdot192\ S$ burning with $\cdot192\ O = \cdot384\ SO_2$ *i.e.*, $\cdot192\ S \times 2220$ Calorific value of $S + O_2$ $= 426\cdot2$
$\cdot42\ Fe \times \frac{8}{10} = \cdot336\ Fe$ burning with $\cdot096\ O = \cdot432\ Fe\,O$, *i.e.*, $\cdot096\ O \times 4478$ Calorific value of $Fe + O$ $= 429\cdot9$
$\cdot922\ N \times \cdot244$ Sp. Heat of $N \times 50°$ Centigrade Temperature at which the air is blown in .... $= 10\cdot3$
$\cdot288\ O \times \cdot24$ Sp. Heat of $O \times 50°$ Centigrade Temperature at which the air is blown in .... $= 3\cdot4$

$869\cdot8$

Loss of heat by decomposition—

$\cdot9\ Fe\,S_2$ into $Fe\,S + S$ *i.e.*, $\dfrac{\cdot9\ Fe\,S_2 \times 88\ Fe\,S \times 200\ (*)\ \text{Calorific value of Fe S combining with S.}}{120\ Fe\,S_2.}$ $= 132$

$\cdot528\ Fe\,S$ into $Fe + S$ *i.e.*, $\dfrac{\cdot528\ Fe\,S \times 56\ Fe \times 634\ \text{Calorific value of Fe combining with S.}}{88\ Fe\,S.}$ $= 213$

Loss of heat of vaporisation—

$\cdot24\ S + 100°\ C$ (*) Heat rendered latent by S becoming vapour .... $= 24$

369

$500\cdot8$

Assuming that the gases pass off from the furnace at 500° Centigrade, and that the specific heat of the slag-producing and metalliferous substances added is ·25, the necessary temperature for the operation being 1000° Centigrade, such substances could be added in the proportion of 20 cwt. to each ton of pyrites Bessemerised.

Thus:—Heat Units as above .... $500\cdot8$

$\cdot48\ S + \frac{4}{10} = \cdot192\ S + \cdot192\ O =$	$\cdot384\ SO_2$	$\times\ \cdot154$ Sp. Heat of	SO_2	$= \cdot05913$
$\cdot48\ S \times \frac{5}{10} =$	$\cdot24\ S$	$\times\ \cdot178$,,	S	$= \cdot04272$
Nitrogen	$\cdot922\ N$	$\times\ \cdot244$,,	N	$= \cdot22497$

$\cdot32682 \times 500°\ C = 163\cdot4$

$337\cdot4$

$\cdot42\ Fe\,S \times \frac{8}{10} = \cdot336\ Fe + \cdot096\ O =$	$\cdot432\ Fe\,O$	$\times\ \cdot137$ Sp. Heat of	Fe O	$= \cdot05918$
Fe S	$\cdot132\ Fe\,S$	$\times\ \cdot136$,,	Fe S	$= \cdot01795$
Foreign matter in Pyrites	$\cdot1$ F M	$\times\ \cdot1$,,		$= \cdot01000$

$\cdot08713$

$\dfrac{337\cdot4}{\cdot08713} = 3872°$ Centigrade.

As above $\cdot0871$
$1\cdot$ ton $\times\ \cdot25 = \cdot2500$

$\cdot3371$ *i.e.* $\dfrac{337\cdot4}{\cdot3371} = 1000°$ Centigrade.

If, instead of employing a cold blast at 50° Centigrade, the air was introduced at 500° Centigrade, a much larger quantity of similar slag-producing and metalliferous substances could be added, viz., 30 cwt. of such substances per ton of pyrites:—

	Heat Units.
In the previous calculation the nett heat units, assuming the gases passed off at 500° Centigrade	$= 337\cdot4$
$\cdot922\ N \times \cdot244$ Sp. Heat of $N \times 450°$ Centigrade difference between the temperature of hot and cold blast	$= 102\cdot1$
$\cdot288\ O \times \cdot24$ Sp. Heat of $O \times 450°$ Centigrade difference between the temperature of hot and cold blast	$= 31\cdot1$
	$470\cdot6$

$\dfrac{470\cdot6}{\cdot08713} = 5401°$ C.

as above $\cdot08713$
$1\cdot5$ tons $\times\ \cdot25 = \cdot375$

$\cdot46213$

i.e. $\dfrac{470\cdot6}{\cdot46213} = 1018°$ Centigrade.

I am indebted to Professor Richard Akerman, of Stockholm, for the following similar calculations, in which it is also assumed that the pyrites contains 90 per cent. $Fe\,S_2$—*i.e.*, 48 per cent. S, 42 per cent. Fe, and 10 per cent. foreign matter. The following are the principal reactions, neglecting the formation of slag:—

$$5\ Fe\,S_2 + 12\ O = Fe\,S + 4\ Fe\,O + 4\ SO_2 + 5\ S.$$

$\cdot48\ S \times \frac{4}{10} = \cdot192\ S$ burning with $\cdot192\ O = \cdot384\ SO_2$, *i.e.*, $\cdot192\ S \times 2220$ Calorific value of $S + O_2$ $= 426$
$\cdot42\ Fe \times \frac{8}{10} = \cdot336\ Fe$ burning with $\cdot096\ O = \cdot432\ Fe\,O$, *i.e.*, $\cdot096\ O \times 4478$ Calorific value of $Fe + O$ $= 430$
$\cdot964\ N \times \cdot244$ Sp. Heat of $N \times 50°\ C$ (*) Temperature at which the air is blown in .... $= 12$
$\cdot288\ O \times \cdot24$ Sp. Heat of $O \times 50°\ C$ (*) Temperature at which the air is blown in .... $= 3$

871

Heat Consumed.

(A). As heat rendered latent by smelting *30
(B). By decomposition:—

$\cdot9\ Fe\,S_2$ into $Fe\,S + S$, *i.e.*, $\dfrac{\cdot9\ Fe\,S_2 \times 88\ Fe\,S \times 200\ (*)\ \text{Calorific value of Fe S combining with S}}{120\ Fe\,S_2.}$ $= 132$

$\cdot528\ Fe\,S$ into $Fe + S$, *i.e.*, $\dfrac{\cdot528\ Fe\,S \times 56\ Fe \times 634\ \text{Calorific value of Fe combining with S}}{88\ Fe\,S.}$ $= 213$

345

*Assumed.

(C). By vaporised sulphur:—

For heating to vaporisation $0 \cdot 24 \times 0 \cdot 178 \times 420°$ .... =	18	
Rendered latent by vaporisation $0 \cdot 24 \times$ *300° .... =	72	
		90

(D). Heat carried off by other gases than sulphur:—

$\cdot 48\ S \times \frac{4}{10} = \cdot 192\ S + \cdot 192\ O = \cdot 384\ SO_2 \times \cdot 155$ Sp. Heat of SO_2 .... =	·0595	
Nitrogen $\cdot 964\ N \times \cdot 244$,, N .... =	·2352	
	$\cdot 2947 \times$ *600° C = 177	
		642
Heat Units remaining		229

$\cdot 42\ FeS \times \frac{8}{10} = \cdot 336\ Fe + \cdot 096\ O = \cdot 432\ FeO \times \cdot 167$ Sp. Heat of FeO .... =	0·072144
FeS $\cdot 132\ FeS \times \cdot 136$,, FeS .... =	0·017950
Foreign matter in Pyrites $\cdot 1$ F M $\times \cdot 15$,, F M .... =	0·015000
	0·105094

$$\frac{229°\ C}{\cdot 10509} = 2179°\ \text{Centigrade.}$$

Professor Akerman has informed me that in his opinion the specific heat of the slag-producing and metalliferous substances to be added would be more probably ·15 than ·25, the figure I have adopted. The necessary temperature for the operation being 1,000° Centigrade, such substances could be added in the proportion of 16 cwt. to each ton of pyrites Bessemerised.

$\cdot 432\ O \times \cdot 167$ sp. heat FeO .... =	·07214
$\cdot 132\ FeS \times \cdot 136$ sp. heat FeS ...... =	·01795
·1 Foreign matter $\times$ ·15 sp. heat F M. =	·01500
	·10509

Metalliferous and slag-producing substances added $\cdot 8 \times \cdot 15$ sp. heat = ·12000

$$\frac{299°\ C}{\cdot 22509}\ \text{i.e.}\ \frac{}{\cdot 225} = 1017°\ C.$$

If the air was introduced at 500° Centigrade, instead of employing a cold blast at 50° Centigrade, a much larger quantity of similar slag-producing and metalliferous substances could be added, viz., 34 cwt. of such substances per ton of pyrites Bessemerised. This would permit of the formation of a less dense slag, which would enable the regulus to separate more completely; for 20 cwt. of pyrites will give about 12 cwt. of iron protoxide, and this dissolved in 38 cwt. of silicious flux containing lime, alumina, and magnesia as principal bases, would give a slag containing, say, 30 per cent. iron protoxide, 30 per cent. alkaline and earthy bases, and 35 to 40 per cent. of silica. This slag would have a specific gravity of about 3·2, while that of 30 per cent. regulus would be 4·7.

	Heat Units.
In the previous calculation the nett heat units, assuming the gases passed off at 600° Centigrade...................... =	229
$\cdot 964\ N \times \cdot 244$ Sp. Heat of $N \times 450°$ Centigrade difference between the temperature of hot and cold blast.......... =	106
$\cdot 288\ O \times \cdot 218$ Sp. Heat of $O \times 450°$ Centigrade difference between the temperature of hot and cold blast.......... =	28
	363

$$\frac{363°\ C.}{\cdot 10509} = 3454°\ C.$$

as above........ ·10509

$$1 \cdot 7\ \text{tons} \times \cdot 15 = \frac{\cdot 255}{\cdot 36009}\ \text{i.e.}\ \frac{363°\ C.}{\cdot 360} = 1008°\ C.$$

The slag formed in the experiments principally consisted of a silicate of protoxide of iron, but contained some sulphur as sulphide of iron. If, after the regulus has been separated from the slag, the latter is further Bessemerised, and thus partly converted into a silicate of peroxide of iron, the sulphide of iron will be entirely oxidised, and the slag consequently will contain no sulphur. The oxidation of the protoxide to peroxide of iron would produce the heat necessary to maintain the slag molten during this operation.

It is probable that the form of furnace eventually adopted will be a modification of the ordinary blast furnace, fitted with a tuyère hearth. Such a furnace, built on pillars, with boshes and hearth of some substance not rapidly acted upon by the slag formed during the burning of the sulphides, would, working continuously, treat a large quantity of material. Being built on pillars, the crucible hearth and tuyère bottom could be replaced when necessary, without disturbing the remainder of the structure, and as these would be the only parts in contact with the fused materials, the furnace from the boshes upward should not experience much wear and tear. When a gannister lining similar to the ordinary Bessemer lining is employed for the boshes and hearth, the corrosive action of the protoxide of iron would be neutralised and avoided by introducing with the pyrites sufficient siliceous material to produce a slag containing at least as large a proportion of silica as compared with the bases, as the formula $2\ RO, SiO_2$. If, however, a basic lining is employed, the slag should contain less silica, and in no case more than the proportion equivalent to the formula $2\ RO, SiO_2$. Under such circumstances the blowing would be continuous, the hot charge coming down to a fusion zone, the height of which over the tuyères would

* Assumed.

be determined by the amount of air blown in, and the frequency with which the blown products are withdrawn, varying likewise with the composition of the charge. The products would be withdrawn by tapping, as with a common blast furnace, the regulus being run off from a reservoir below the tuyères, where it would collect, and being thus unacted upon and undisturbed by the blast, rich regulus, or even metallic copper, could be produced. By continuing the oxidation, and producing Cu_2 S, and some metallic copper, the gold and silver would be found with the metallic copper. It is well known that small quantities of silver and gold are far more completely extracted from minerals which contain them by smelting, or treatment with fluid metal or metallic regulus, than by any wet process. The fact that by such methods, practically the whole of these metals present are collected and concentrated, is the fundamental principle of the analytical assay, and is proved by the accuracy of determinations made in this manner. A large side flue, at the top of the furnace, would carry off the gases and sublimates after their temperature had been reduced in heating the charge introduced above through a self-closing hopper. It is calculated that such a furnace, 30 or 40 feet high, with a a hearth capacity of 1 cubic metre, would be capable of treating annually 50,000 tons of pyrites, and a similar quantity of silicious fluxes, working 200 days in the year.

The theory of smelting sulphides with a blast furnace is as follows :—The operation is started by placing the tuyère hearth in its place, and throwing in hot coke at the top of the furnace. The blast is now turned on, and the coke developes a high temperature by its rapid combustion. The ordinary working charge of sulphides and fluxes is now introduced at the top hopper, and as the sulphides melt the coke burns away. As soon as a layer of molten sulphide lies over the tuyères, the blast is increased, and also the burthen of the furnace. The charge above the fusion zone as it descends is gradually heated, losing much of its sulphur by volatilisation before it becomes molten. On fusion, a considerable amount of lead sulphide will distil over, accompanied by the remainder of the arsenic as sulphide in the strong current of nitrogen and sulphurous acid. These gases, as they pass upward in the furnace, will be greatly reduced in temperature by the volatilisation of the sulphur and moisture from the crude materials. There is some reason to believe that more than half of the sulphur in pyrites is volatilised in the free state by this operation. The sublimed oxides, sulphides, and sulphur would be collected in the wide chambers with which the side flue is connected. Below in the hearth the oxygen of the air forced in acts upon the sulphides of iron and zinc contained in the charge, and as long as a constant supply of these substances arrives at the hearth no other constituents present will be appreciably oxidised. A tap hole near the top of the hearth allows the slag to be withdrawn. The blowing would be continuous day and night so long as the tuyère hearth lasted, and the heat from the gases after they leave such a furnace could be utilised so as to heat the blast or to produce steam power for the blowing engines. The produce of about six tons of material would be tapped every half-hour, so that in seven days' work 1,000 tons of pyrites-bearing sulphides would be treated. If desired, the products could be run direct into suitable reverberatory furnaces, when, after the regulus had subsided, the slag could be run off while yet in a molten state, and in which the oxidation of the regulus could be completed. It is difficult to see how the charge could be overblown, but if it were, the product could be worked up again by adding it to a subsequent charge of sulphides introduced at the top.

The sulphurous acid evolved could be oxidised into sulphuric acid in chambers, or reduced to sulphur by sulphuretted hydrogen. The latter decomposition might be accomplished by driving superheated steam into the furnace where the sulphides are oxidised. The sulphurous acid could also be utilised by Mr. Hargreaves' process, and there are other possible methods of treatment, such as dissolving the sulphurous acid in water by spray jets in towers, or by condensing the gas to the liquid state. I am indebted to Mr. A. H. Allen, F.C.S., for indicating to me a means by which large quantities of liquid anhydrous sulphurous acid can be produced, from which sulphuric acid free from arsenic could be made. This plan appears to me simple, and offers many advantages, so that I venture to give it somewhat in detail :—

"The gases, freed from impurities mechanically carried over with them, are first cooled and then led into towers, or other suitable vessels, filled with charcoal, which will absorb and retain the sulphurous acid and allow the nitrogen to escape. The sulphurous acid is afterwards obtained from the absorbent by exhaustion or heat, and, being thus practically free from nitrogen, can more readily be liquefied by compression than is possible in the presence of a large quantity of that gas. The sulphurous acid having been extracted, the charcoal will be ready for another operation, and may thus be used many times in succession."

It is evident that any such plan for producing liquid sulphurous acid at a moderate cost may open out new branches of industry. It is well known that in many instances intense cold, such as can be obtained by the volatilisation of sulphurous acid, can be used for separating by crystallisation certain salts from their solutions. There are also other purposes for which it is applicable.

The following are calculations showing the cost of plant and working expenses for the treatment in Spain of 300,000 tons of pyrites containing not less than $1\frac{1}{2}$ per cent. of copper :—

The coal necessary to produce the cold blast would be about 20,000 tons, and further 11,000 tons to heat it to 1,000° Farenheit.

One ton of pyrites contains, say—90 per cent. Fe S_2 and 1·5 per cent. of copper.

·90 Fe S_2 = ·66 Fe S, of which ·60 has to be oxidised. Of the remaining ·06 Fe S ·03 passes into slag as iron protosulphide (probably combined) and ·03 is left with the regulus. Under these circumstances, the regulus will contain upwards of 30 per cent. of copper.

Thus—·030 Fe S + ·015 Cu = ·045 of regulus, containing ·015 Cu or $33\frac{1}{3}$ per cent.

Now—·60 Fe S requires ·327 O for the reaction Fe S + O_3 = Fe O + SO_2.

Oxygen exists in air in the proportion of 23·5 per cent. by weight.

Therefore—23·5 : 100 : ·327 = 1·391.

Or, 1·391 tons of air are required per ton of pyrites, 1·6 tons have been calculated upon to ensure an excess.

I am indebted to Messrs. Howson and Wilson for the following information:—

Middlesboro'-on-Tees, Dec. 3, 1878.

"Assuming that 1·6 tons of air is required per ton of pyrites, the amount of air to be blown in will be 480,000 tons per year, and reckoning 50 weeks of 160 hours each as working time, this is equal to one ton per minute of air required. This equals 29,300 cubic feet, and would be blown by engines whose blowing pistons have a collective area of 11,309 (say, eleven thousand three hundred and nine square inches) with a piston speed of 374 feet per minute. We have referred to diagrams from the Bessemer blowing engine cylinder, and find when blowing 25 lbs. blast the average pressure is 17 lbs., therefore in your case $\frac{11,309 \times 17 \times 374}{33,000}$ = 2,178 indicated horse-power, and adding 10 per cent. for the friction of the engine, 2,395 indicated horse-power."

"If the engines were of the compound type, so as to ensure economy, they would not use more than 2 lbs. of coal per hour per indicated h.-p. This equals 2,395 × 2 = 4,790 lbs. = 2·13 tons per hour, and in 8,000 hours per year, 17,040 tons per annum.

"This, the very least that should be calculated upon, would probably in practice reach 20,000 tons per annum.

"Each indicated horse-power would require, say 22 lbs. of water to be evaporated per hour, or for 2,395 h.-p. 52,690 lbs. of water per hour. Each square foot of boiler-heating surface would not evaporate more than 5 lbs. of water per hour, therefore 10,538 square feet of heating surface would be required, and this should be contained in, say, 20 boilers of ordinary size. We should therefore provide at least 23 boilers so as to allow for cleaning and repairing."

"It is now a question for you to consider whether it will pay to heat this blast by stoves fired with coal. The amount of coal required to heat the air for blowing 300,000 tons per annum to a temperature of 1,000° Fahr. would be, if well-conducted stoves were used, 11,000 (say, eleven thousand tons per annum)."

I am also indebted to the same friends for plans and estimates of cost of plant.

"Middlesboro'-on-Tees, Dec. 24, 1878.

"We herewith send you an estimate of the plant, tracings of which we forwarded you yesterday marked A and B. You will, of course, understand that it is only a provisional one, at the same time we think that unless you make the buildings of a more expensive character than we contemplate, the entire job should not cost more than—say £150,000. You will note that we have estimated the number of boilers required at 16 instead of 20. This is because we considered that in reality the pressure of blast required will be much less than what we founded our first calculation upon.

Estimated Cost of Plant to Treat 300,000 tons of Pyrites per annum by Hollway's Process.

16 Boilers, complete, with setting and mountings	£10,260
Roof over boilers	1,500
Four chimneys	2,800
Three pairs of compound condensing blowing engines	9,200
Engine house	2,000
Steam and water pipes and feed pumps	1,000
Floor, gallery, and staircase in engine house	500
Hot and cold blast mains—100 tons and lining ditto	2,300
8 Whitwell's stoves	8,000
Gas and smoke culverts	4,000
Gas producers and coal stage	3,500
42 Down corners and valves	840
14 Blowing converters and depositing chambers .... £750 each	10,780
15 Regenerative regulus furnaces £500 each	7,500
330 Tilting ladles on wheels .... £50 each	16,500
150 Bogies for receiving regulus and slag	5,250
2 Steam cranes	1,600
6 Storing bunkers	3,600
Brickwork extra to ditto	550
Gangway over bunkers	1,200
70 Small tubs for converters	1,050
Converting house	3,000
Regulus shop	5,500
2 Depositing pits	1,200
Extra drains and foundations	1,500
2 miles for railway, 4-8½ gauge	6,000
1 Mile narrow gauge ditto	1,500
20 Turntables	800
Overhead tramway to converters	600
Blacksmiths' and other shops	2,000
Water-pipes, boshes, tools, &c.	2,000
Weighing machines	500
Excavation	5,000
Locomotives	4,000
Freight of materials from England, say, 600 tons, at 15s. per ton	4,500
Contingencies	5,000
	£137,030"

Estimated Value of Principal Products.

Regulus.—300,000 tons pyrites, containing not less than 1½ per cent. copper, 1 oz. 11 dwts. 8 grs. silver, and 3 grs. gold per ton of pyrites, should produce 15,000 tons of regulus, containing 30 per cent. copper, 15 ozs. 13 dwts. 8 grs. silver, and 1 dwt. 6 grs. gold per ton of regulus; but the quantity is somewhat less, because there is a small loss of copper in the slag, which, however, should not exceed 10 per cent. of the total copper. 13,500 tons 30 per cent. or 15,000 tons 27 per cent. copper = 4,050 tons of copper, at £60 per ton = ...	£243,000	
13,500 tons 15 oz. 13 dwts. 8 grs. of silver = 423,000 ozs. of silver at 4s. per oz. =	84,600	
13,500 tons 1 dwt. 6 grs. of gold = 1,687½ ozs. of gold at £4 per oz. =	6,750	
	£334,350	
Deduct the cost of separating the copper, gold, and silver from the regulus, say	84,350	
		£250,000
Sulphur.—300,000 tons of pyrites would produce 72,000 tons of crude sulphur, *i.e.*, 300,000 tons × ·24 = 72,000 tons at £3 per ton =		216,000
		466,000

Cost of Pyrites and Estimated Expenses Producing Regulus, &c.

Pyrites.—300,000 tons, at 6s. per ton	£90,000
Coals.—300,000 tons pyrites, requiring 18 tons of coals, at 23s.	

per ton, for every 100 tons of pyrites $\frac{300,000 \times 18 \times 23s.}{100}$ =	.. £62,100	
Silica.—If ordinary sand or siliceous will be rock is employed, 1 ton required to every 3 tons of pyrites $\frac{300,000}{3}$ = 100,000 tons at 5s. per ton ....£25,000 In these calculations, however, an extreme case is taken, viz., that the silica might be taken from the linings of the vessel, and, therefore, a larger quantity must be calculated on, as sand cannot be used alone for the linings. 150,000 tons are, therefore, estimated as the quantity that might be required. Cost, including labour of lining and tuyères, 10s. per ton	75,000	
In actual working at least two-thirds of the above amount of £75,000 will be saved, because siliceous materials containing valuable metals will be introduced with the protosulphide, and in this way the linings will be saved and additional valuable metallic products will be thus obtained and utilised.		
Wages, &c.—300,000 tons of pyrites, at 1s. per ton	15,000	
Carriage of regulus to England.—300,000 tons pyrites, *i.e.*, 13,500 tons of regulus at 20s. per ton	13,500	
Contingencies, including depreciation of plant and interest	45,400	301,000
300,000 tons of pyrites containing only 1½ per cent. of copper thus treated should therefore yield at least 11s. per ton profit........		£165,000

In the foregoing calculations I have intentionally omitted taking into account the values of the sublimates other than sulphur, the sulphurous acid evolved, and the valuable metals contained in the slag-forming materials added.

The substances volatilised will probably consist of varying mixtures of arsenious sulphide, lead sulphide, and oxide of zinc, also, possibly, sulphide of the latter metal. There may be also small quantities of sulphide of thallium and oxide of iron, which may for practical purposes be neglected. Sulphur and sulphide of arsenic are readily vaporised in a current of non-oxidising gases at a low red heat (500° Centigrade), while sulphide of lead, as also oxide and sulphide of zinc, distil very slowly under similar circumstances, the greater part of the zinc and lead should, therefore, be found in the first sublimate chambers, while the sulphur and arsenious sulphide would deposit further on.

300,000 tons of pyrites would also produce (in addition to about 72,000 tons of crude sulphur) about 120,000 tons of sulphurous acid. The cost of collecting and liquefying the sulphurous acid would be less than fifteen shillings per ton, after setting aside 15 per cent. to cover interest and depreciation of plant and making a liberal allowance for repairs, the requisite fuel being calculated on the basis of twenty-three shillings per ton.

I am indebted to Mr. David Cowan, C.E., Glasgow, for the following information:—

"The cementation process is at present employed in Spain, by which about 85 per cent. of the copper from pyrites is obtained at a cost of about thirteen shillings and sixpence per ton on the pyrites treated: viz., about 65 per cent. by lixiviation in the tanks, and further 20 per cent. afterwards from the resulting residue; the remaining 15 per cent. of the copper being practically lost, while the sulphur passes into the air as sulphurous acid, causing great damage to property, besides the entire loss of the sulphur.

"Thus 100 tons of pyrites containing 1·5 per cent. copper would produce about 1·275 tons of copper at £60 per ton ....=	£76 10 0
Cost of extraction—100 tons at 13s. 6d. per ton	67 10 0
	£2 0 0

"Therefore, the profit on each ton of pyrites containing 1·5 per cent. of copper is less than one shilling and ninepence per ton, and on a similar basis the cost of thus treating pyrites containing two per cent. of copper is 15s. 5d. per ton, but the profit would be 4s. 7d. per ton.

"This process is only employed for treating the poorer ore raised from the pyrites mines, and is carried on in their vicinity. It is divided into three principal operations, viz., calcination, lixiviation, and precipitation, and was first introduced at the Rio Tinto Mines by Alvaro Alonso de Garcias, in 1661. On the whole, it is very suitable for the treatment of the poorer pyrites ores for copper. It does not require much skill on the part of the labourer, nor does it involve the use of any very costly materials or complicated appliances. The cost, when the process is intelligently carried out, is moderate. These, doubtless, are no slight advantages, but the process has many disadvantages, especially where large quantities require to be dealt with.

"1. It seldom happens that an ample supply of water can be obtained from any source, and, in consequence, these works are often stopped, wholly or in part, for several months yearly.

"2. When rain falls it usually comes in large quantities. During these periods the drainage from the calcination ground, waste heaps, and mineral stock heaps is highly impregnated with copper, and is so great that it cannot be overtaken in the precipitating tanks, so that much copper is lost.

"3. The fumes from the calcination of such large quantities of pyrites impregnate the air for miles around, and completely destroy all vegetation within its influence. The works at all times are more or less affected, and the suspension of some part of the process takes place with more or less frequency.

"4. The copper in the ore only is available, the iron, sulphur, gold, silver, &c., which form about 98 per cent. of the mineral, are either lost altogether, or, at least, rendered useless for any practical purpose.

"5. The process being only suitable for the poorer ores cannot be advantageously applied to richer ores, containing from three to four per cent. of copper and upwards.

"6. Government and local authorities are averse o the extension of the process to districts where it is not now in use, on account of the evils arising from the fumes and the pollution of streams, so that its use in Spain is restricted to situations where it is already established. In Portugal it is prohibited altogether.

"7. The works are scattered over a large area, and the whole operation embraces many separate operations from the time the crude ore enters the calcination ground to the exit of the finished product. During the whole of this time (about twelve months) it is subject to many influences which sensibly tell as a loss on the narrow margin there is for working upon. Rain, leakage, imperfect

calcination, lixiviation, and precipitation, considerably affect the working costs, and necessitate on the part of those in charge continued watchfulness and vigilance. A slight neglect to either of these details may make all the difference between a profit and a loss on the operation. The apparent simplicity of the whole seems to have a wonderfully fascinating influence on such as come in contact with it for the first time, or who have only an indirect connection with its working. The conditions favourable for obtaining the best results can by no means be secured at pleasure, by simply adopting certain fixed rules and practices; on the contrary, the ever-changing conditions incident to the system prevent the adoption of fixed mechanical routine. Though the continued maintenance of the most favourable working conditions is possible, the mode of operating is one that requires much judgment, and in practice it is very difficult to obtain them, and these difficulties never seem to have been thoroughly realised by those most interested. The process has continued practically unchanged in Spain for about 220 years, and apparently without any serious efforts towards its improvement. Anything which would shorten the process, reduce the number of operations, and the area occupied would be hailed as a great step in advance, and if in any way the evils of the smoke nuisance could be mitigated, although there were no great diminution of costs, the benefits to the country would be incalculable, and new fields for industry, now completely neglected, would open out."

The importance of this subject may be estimated from the fact that one and a-half to two million tons of pyrites are raised annually by the Rio Tinto Company, the Tharsis Company, and Messrs. Mason and Barry. Upwards of 600,000 tons of this quantity are imported annually to this country, and employed in the manufacture of sulphuric acid. About one million tons are annually burned at the mines. It may also be interesting to mention that in South America, Cuba, Australia, the Cape of Good Hope, and in many other places, there are large quantities of poor copper ore containing 5 per cent. and upwards of copper, which are thrown aside as unsuitable for smelting on account of the cost of fuel, and from which the copper is only partially extracted by the cementation process.

I have thus endeavoured either to prove by experimental data, or to logically demonstrate:—

First. That the whole of the oxygen of the air driven into a thin stratum of protosulphide of iron, Fe S, is utilised for oxidation.

Second. That by the heat evolved in the rapid oxidation of sulphides, and without the use of extraneous fuel other than that employed in producing the blast:—

(A.) About one-half of the sulphur contained in iron pyrites, $Fe\ S_2$, is expelled in the free state.

(B.) The remainder of the sulphur, excepting that left with the regulus, is principally evolved as sulphurous acid.

(C.) Although only about 20 per cent. of sulphur is oxidised, the proportion of sulphurous acid to nitrogen by the new process is 14·9 per cent., which is a larger proportion of sulphurous acid than is obtained by copper smelters who manufacture sulphuric acid. In the ordinary method of burning pyrites, where 45 per cent. of sulphur is oxidised, the ratio of sulphurous acid to nitrogen is only 16 per cent.

(D.) The volatile metallic sulphides, such as arsenic sulphide and lead sulphide, are distilled off with sulphur.

(E.) Iron being more oxidisable than copper, silver, gold, nickel, and certain other metals, these latter will be all concentrated in the regulus, provided an excess of sulphide of iron is always present.

(F.) The protoxide of iron thus formed is converted into slag by the addition of the silica introduced with the pyrites.

(G.) The more perfect fusion of the slag thus obtained prevents loss of copper by entanglement with imperfectly fused material.

(H.) About 16 cwt. to 20 cwt. of incombustible material, having a specific heat of ·15 to ·25, can be added per ton of pyrites when a cold blast is employed, assuming that 1000° Centigrade is the temperature necessary for the operation.

(I.) The quantity of similar incombustible material can be increased to from 30 to 34 cwt. to each ton of pyrites operated on, when a hot blast of 500° Centigrade is employed, assuming that 1,000° Centigrade is the temperature necessary for the operation.

(J.) Such incombustible material may contain larger or smaller quantities of valuable metals as oxides which will pass into the regulus or be volatilised as sulphides, after double decomposition with protosulphide of iron present in the molten bath. Thus silicates of nickel or copper would be converted into sulphide of nickel or copper, and be concentrated in the regulus.

Third. That when employing a siliceous lining for the furnace the corrosive action of the protoxide of iron formed is greatly mitigated, if not practically avoided, by the addition of sufficient silica with the charge of pyrites to produce a slag containing more silica than is required by the formula $2\ (MO)\ Si\ O^2$ (M representing an atom of divalent metal).

Fourth. That the quantity of coal necessary to produce the blast, calculated on the oxygen requisite for the oxidation which takes place, is $1\frac{1}{3}$ cwt. per ton of pyrites.

Fifth. That to heat the blast to 500° Centigrade an additional amount of less than 1 cwt. of coal per ton of pyrites is sufficient.

Sixth. That the new process would materially avoid the destruction of vegetation now so bitterly complained of in Spain, and, at the same time, would greatly increase the profits of the pyrites companies who now employ the cementation process.

Seventh. That the new process could be advantageously employed by the copper smelters for treating rich copper ores on account of the great economy there would be in labour and fuel.

Eighth. That the cost of plant is small, compared not only with the quantity of material it would treat, but also on account of the additional profits derivable from the new process.

I trust you will kindly consider the correctness of my deductions in the order in which they are stated, as it would be useless to waste your valuable time in the discussion of the practical possibilities of the process, if on consideration you decide that the first, second, and third statements are materially incorrect.

In concluding this paper, I wish gratefully to acknowledge the assistance I have received from so many friends. To Mr. Hugh M. Matheson, chiefly at whose expense the Bessemer experiments have been made; to Mr. George Wilson, the managing director of Messrs. Cammell and Co., for the facilities and assistance afforded me, and also to the managers and *employés* at their Penistone Works; to Messrs. Edward Riley, J. E. Stead, and A. H. Allen, and to our chemist, Mr. A. E. Arnold, for their advice and assistance in carrying out the experiments; to them I am also indebted for the analyses; to Dr. W. M. Watts, for spectroscopic observations; to Mr. J. J. Wright (from Siemens Bros.), for the pyrometer measurements; to Messrs. Howson and Wilson, of Middlesboro', for the working plans and estimates for practically carrying out my process; and also to Mr. Howson for personally attending the experiments, and for the valuable suggestions he has given me. I also take this opportunity of thanking the friends who assisted me in the earlier experiments, also all those who have so often helped me by corrections and advice.

DISCUSSION.

Mr. Hollway read a letter from Mr. Hussey Viviau, regretting his inability to be present, and expressing his belief that the Bessemer process was quite inapplicable to copper smelting.

The Chairman said he believed he owed his position that evening to having been able to go over to Penistone last week to see the experiments carried on at the works of Messrs. Cammell and Sons, as described in the paper, and they were certainly most interesting and instructive. He would suggest, however, that the words "Bessemer process" should be omitted from the title, inasmuch as although it was quite true that the principles upon which that process was founded were those which led Mr. Hollway to the results which he had brought forward, and although the Bessemer plant had been employed in the experiments hitherto; yet it should be understood that it was not the intention to employ it when the process was carried on on a practical scale. He understood that only half of the experiments with regard to this process had yet been tried; only the possibility of carrying on the rapid oxidation of sulphides had been at present tried in the Bessemer converter, but it was not the intention to employ that converter hereafter, because, in that plant, it was impossible to condense the sulphur which in the process ought to be saved. This could only be done by the use of a cupola, or blast furnace, into which a limited quantity of air would be blown, thus bringing about the necessary oxidation and volatilisation of the sulphur, which would be collected in the free state. If all the sulphur were to be lost, the great value of the process would be gone. He would first ask the meeting to discuss the first point of those enumerated in the paper, and would call upon Mr. Arnold, who had had a great deal of experience, to give the facts of the case, and the proofs on which the statements in the paper were based.

Mr. Arnold said that on the question whether the gases which came from the mouth of the converter contained oxygen or not, depended the possibility of obtaining a large amount of sulphur. If free oxygen existed in these gases, free sulphur could not exist. The gases were drawn off from the mouth of the converter by means of a large aspirator, through two gas tubes placed side by side, and the apparatus was so regulated by means of taps, that by turning two taps the gases which came off at a given moment, could be enclosed in these two gas tubes. By that means duplicate samples were obtained, though duplicate analyses could not be made because, unfortunately, one tube got broken; the contents of the the other had been used for a rough determination. They took about 60 gas tubes, but only a few contained gases in the proportion in which they came off from the converter. They had to fit up a long piece of iron gas tubing, screwed end to end, and the joints made good, and through this the gases were drawn. A little clay bell was used, which was screwed on to the end of the iron tubing, the whole being well protected by means of sand. The end of this bell was placed exactly in the centre of the gases issuing from the converter. If it had been placed at the side where the issuing gases burned by means of the oxygen of the air he should have expected to find that the gases contained a much larger percentage of sulphurous acid than was really obtained from the process; but they were taken from the centre. By this means he collected the tubes of gases which were sent to be analysed, and the percentages estimated. They came out about what was calculated, viz., about 14 per cent. of sulphurous acid, whilst, theoretically, it was 14·9, which would be reduced somewhat by other reactions which took place. In the analyses given, it would be seen that one contained some oxygen; but that, probably, got accidentally into the gas tube, because he wished to take one tube right at the end of the blow; and of course the vessel from which the gases were issuing was being continually moved, and this occurred at the very moment the tap was turned, and so a little air probably got in. Those two tubes were sufficient to show that when a stream of air was blown through a thin stratum of molten protosulphide, you obtained gases which contained no free oxygen.

Mr. Stead (Middlesboro') said he had beeu present at all these experiments. He thought all chemists who had ever tried the action of the cold blast of air ou the top of a mass of fluid protosulpide of iron must have noticed that the air had its oxygen very rapidly extracted from it, by the sulphur and iron in the sulphide; in fact, he had noticed that the sulphide became very much hotter where the cold blast had been, showing most clearly that the oxygen was very rapidly and readily abstracted from the air under those circumstances. There could be no doubt, therefore, that air in passing through a small column of protosulphide of iron had every trace of its oxygeu removed.

Mr. Riley said he had had an opportunity of witnessing all these experiments, which he had carefully watched. He would turn his attentiou to what appeared to him to be the practical difficulties of the operation. Theoretically, there was uo question that, by passing oxygen through molten sulphide of iron, we did get protoxide of iron and sulphurous acid. As to whether the whole of the air from the blast forced into molten sulphide of iron was deoxidised, it seemed to him a very simple matter depending on the regulation of the blast; you might blow too much, and not get the whole blast oxidised, but, if you regulated it properly, there seemed to him no difficulty in carrying it out practically. Then, coming to the question of how to treat it in a practical way, there was the fact that when you so treated protosulphide of iron, the results of that action on the vessels in which you carried out the operation were well known, and this was one of the first difficulties to be overcome. The actiou of protoxide of iron on any vessel lined with sand or silicious material was very serious. This was more or less neutralised by the addition of a certain amount of sand during the operation, but still it appeared to him that there would be some little difficulty iu getting a lining that would stand the operation. He had tried some of the first experiments iu the Bessemer process, and then thought that one could get nothing to stand the fluxing actiou of the protoxide of iron, but the

difficulty was soon got over, and he felt a great deal of confidence that this difficulty also would be got over. Silica appeared to him not exactly the right thing to use. At present a great deal of attention was being directed to the lining of Bessemer converters with a basic material, such as lime in some form or another, and it seemed to him that either lime or a lining of oxide of iron, such as was used in the rotary puddle furnace, was one which would stand, but this was a matter which could be worked out practically. Then as to the temperature. There was no question that, if you started with molten protosulphide of iron (the pyrites melted in the cupola), you could, by adding more pyrites, evolve sufficient heat to melt it and drive off the sulphur. If you did not add sand an action took place simply upon the vessel you used, and it supplied itself with sand. This was shown by the results of two experiments, in one of which sand was added, and in the other no sand. The two cinders were in one ladle identically the same, as would be seen on examining the samples on the table, and it would be found that they really were a silicate of iron of the composition $2 Fe O Si O_2$. They were beautifully crystallised, and he considered it a definite chemical compound. In making experiments such as these, he always valued the information from those who were practically and daily in the habit of judging of temperature. In some of the experiments, those carrying them out were a little too eager, and overdid the thing, and gave the converter too much to do; but one was made by a gentleman at the works accustomed to temperature, and he certainly did carry out the experiment perfectly. The vessel would be the first practical difficulty to be got over, and then the question of collecting the sulphur would arise. If the blast were so regulated that the oxygen was completely removed from the air, a certain amount of sulphur would be got which could be condensed; but, with regard to the sulphurous acid, that seemed to him not quite so easy a question. He thought you could condense the larger portion of sulphur. In all the experiments the vessels used for pouring out the mixture of cinder and regulus were not adapted for the purpose, and although we got some very good regulus, at the same time a certain amount was enclosed in the cinder, and the difficulty was tipping the converter properly, and emptying the cinder and regulus in the ladle. The very best part that was left behind in the converter was difficult to get into the ladle, and in some cases it had to be thrown into the pit below, but he thought that, with a small plant, this process could be adopted practically, namely, by the use of a sort of cupola with a moveable bottom and means for collecting the sulphur. The regulus on the table contained over 40 ounces of silver the ton, and $50\frac{3}{4}$ per cent. of metallic copper. It seemed to him that experiments should be made on some plant more adapted to the purpose than the Bessemer plant, which was very expensive, and, in his opinion, not well adapted to the purpose.

The Chairman asked what was the per-centage of copper contained in the pyrites.

Mr. Riley said about 1·8 per cent. by the wet assay; perhaps by the dry assay it would be about $1\frac{1}{4}$ to $1\frac{1}{2}$ per cent. He intended to see what the dry assay would show, but it was always considerably lower than the wet. In one converter they kept throwing in the pyrites, and when it was partially burnt, it was turned down, and the cinder tipped out, not giving sufficient time for the sulphide of iron to be oxidised, as was shown by a certain amount of it being found in the cinder unoxidised. The point he wished specially to call attention to was the results of the two experiments, with sand and without.

The Chairman then invited discussion on the secon head.

Mr. Stead said the heat produced by the oxidation o protosulphide of iron was very clearly demonstrated in the experiments at Penistone last week. In one experiment, he himself acted the part of foreman stoker, and regulated the temperature by introducing the proportion of pyrites and sand. At one time he a little overdid it, and when the vessel was turned down to examine the state of the contents, it was found that they were in a decidedly pasty condition. They turned it up, however, and refrained from adding any more pyrites, and blew for about ten minutes, at the end of which time the whole mass had very considerably increased in temperature, and was as fluid as water, giving conclusive proof that the oxidation of the sulphides had produced a considerable amount of heat. As to the amount of sulphur driven off, there could be very little doubt that the conditions existing inside the vessel were very similar to what would occur if you put pyrites into a crucible, and heated it in an atmosphere free from any oxidation. Half of the sulphur would be driven off. At the top of the bath of metal in the converter you had only free sulphurous acid and nitrogen, or free sulphur, and consequently you had conditions as favourable for distilling off half of the sulphur, as you would have in a crucible. As to proposition B, there could be no doubt that, on continuing the action of air, all the sulphur would pass off as sulphurous acid, except that which was left in the regulus. He should like to correct a remark he had made on the first question, that the whole of the oxygen of the air driven into a thin stratum of protosulphide of iron was utilised for oxidation. Of course, as Mr. Riley had said, it would depend upon the rate at which the current was driven in, but he thought it depended much more on the diameter of the column of air. If you blew the air through the bottom of the converter through a hole a foot in diameter, the greater portion would pass up through without being acted on. He had referred to the conditions actually present in the experiments. If the air were in a sufficiently thin stream, the whole of the oxygen would be removed.

Mr. Lomas asked if actual condensation of one atom of sulphur took place?

Mr. Hollway said no, it did not; it was allowed to pass off into the air, and was burnt coming out. There was no arrangement made for condensing the sulphur.

Mr. A. H. Allen (Sheffield) had had the good fortune to be present at the experiments at Penistone, and he certainly had been very much struck with the ingenuity of the notion, and the perseverance and energy with which the matter had been carried out. He came to the conclusion that, if the process were not a commercial success, it would not be for want of trying to make it so, and certainly, from a scientific point of view, it was of the utmost possible interest. He was accustomed to witness metallurgical processes on a large scale, but he was certainly astonished, though he was a chemist, to find that the temperature could be kept up in the perfect manner in which it was found possible to do it, hour after hour, by literally feeding the converter with stones, for that was the impression it gave one. There was an old saying about asking for bread and receiving a stone, but in this case instead of feeding it with coal for ten hours or so, they gave the converter nothing to eat but pyrites and sandstone, introduced in lumps rather larger than he liked to see, but it ate them all up and digested them. In one experiment they certainly added the pyrites in rather too large lumps, and the result was that, as it was added very quickly, the temperature became so reduced that coal had to be thrown in to remelt it, but that was when a large amount was added in about 40 minutes. When the same quantity was added in the course of an hour, and in smaller lumps, the process went on quite satisfactorily. With respect to the question of entire deoxidation of air by passing through, he would submit that it was by no means extraordinary that it should occur. Every-

one familiar with the metallurgy of iron was aware that, within a few inches of the tuyères of the blast furnace, the gases contained no free oxygen, but there the conditions were very inferior for deoxidation to what you had in this process. In the blast furnace the materials sinking down contained 25 to 30 per cent. of carbon, the rest being ore and limestone, so that the combustible material was not more than 30 per cent. of the total weight. On the contrary, in Mr. Hollway's process, in the molten material in the converter there was 40 per cent. of sulphur, and 45 of iron, being 85 per cent. of combustible matter, which gave it a much better chance of acting on the air. Besides that, the air was bubbling up through the liquid material, and was brought thoroughly in contact with it. With regard to the heat produced, he would point out that with the blast furnace, the deoxidation of the ore to metal occurred in the higher parts of the furnace by the action of carbonic oxide gas. Near the tuyère you had carbon burned to carbonic oxide, and only slowly burned to carbonic acid; now carbon burnt to carbonic oxide only evolved 2,400 units of heat, and even if some of it burned to carbonic acid it would only evolve 5,600 units of heat more for every unit so burned; but when you burned iron to ferrous oxide you obtained 4,478 units of heat by the combustion of iron to protoxide, and when you burned sulphur to sulphurous acid you obtained an additional 2,400 units; so that if you took an equal weight of coke and of pyrites, you would find that by the formation of sulphurous acid you got nearly as much heat as you did by burning as much coke. People thought this was a question of burning sulphur, but it was a question of burning iron as well; and you got twice as much heat by burning iron as you did by burning sulphur. In making these experiments, it is necessary to have an excess of sulphide of iron. It was highly probable if you went on you would end by burning out the whole of the iron and too much sulphur, and you would obtain, as was actually obtained, metallic copper; and in such cases you might expect that a certain amount of copper would pass into the silicate. In practice, all you could do was to obtain a comparatively rich material with, perhaps, 25 to 30 per cent. of copper. According to the most reliable calculation, it seemed that all but about 8 per cent. of the copper was accounted for by what passed into the silicate and regulus, and what was left in the cupola. Some of what disappeared was, no doubt, lost in splashing over, in what got tipped into the bottom, and in unavoidable loss by an apparatus used on a large scale for what it was never intended for. He thought that copper volatilised towards the end of the process. They knew some did, because a series of beautiful spectroscopic observations were made by Dr. W. M. Watts, who found that when overblown, a sensible amount of copper was volatilised, as appeared in the spectrum, and the colour of the flame entirely changed at that period of the blowing. During the ordinary operation of blowing they did not see those copper lines. That was interesting, because the flame had a greenish colour. He believed that greenish colour to be an optical effect produced by the reflection from the white light of the interior of the converter upon the orange sulphur vapour and the outer cone of blue sulphurous acid. A long flame of sulphur came out of the converter, which was not smelt, simply because it was all allowed to pass up the chimney. A question was asked how they knew that sulphur was given off. He knew it, because he was in front of the converter on one occasiou when it was turned down, while the blast was still on, the upper part of the vessel was seen to be filled with orange vapour of sulphur, which when it came to the mouth burned with its characteristic blue flame. He would defy anyone to account for the big blue flame at the mouth in any other way. Another proof was this, Mr. Arnold in his experiments found that the sulphur choked up his tubes, they were continually filled with deposits of metallic sulphides and free sulphur.

Mr. Arnold wished to say, that the pyrites was not thrown into the vessel, but was first melted in a cupola, and the one atom of the sulphur in the crude mineral was thus driven off. When that protosulphide was run into the converter, and a current of air driven through it, a large blue flame was seen issuing from the mouth of the converter, and he could not think of any other substance which could cause that except the vapour of sulphur. Half having been driven off in the cupola, he would suggest that more than half the sulphur from the sulphide introduced into the vessel, passed off in the state of sulphur vapour. With regard to the gases, there were one or two of the identical gas tubes he used on the table.

The Chairman said it would be hardly necessary perhaps to discuss "C," the calculations in proof of which would be found in the paper. He might say, however, with regard to the question put by Mr. Lomas, that he believed that Mr. Wright was present, who had taken the temperature by Siemens' pyrometer, which was ascertained to be below the fusing point of cast iron; but when placed in the flame it was found very quickly to melt, proving very definitely that the flame did consist of sulphur.

The Chairman next invited discussion on head "D".

Mr. Arnold said there were specimens of volatilised sulphide of lead and one or two other metals on the table. Sulphide of lead was volatilised to a considerable extent in a current of reducing gases, for he had produced this effect in a current of steam in an iron tube heated to a much lower point than that obtained in this experiment. The greater part seemed to have been volatilised and carried over, and it would naturally condense sooner than the more volatile sulphur. There was very little lead left in the products.

The Chairman asked what was the percentage of lead in the crude ore?

Mr. Arnold said he thought about 5 per cent.

Mr. Riley said it was only 1·32 per cent. in the last experiment.

Mr. David Cowan said the samples varied considerably; in some cases there was a high per-centage, and in some none at all.

The Chairman having invited discussion on head, "E",

Mr. Riley said he wished to remark on the very unfavourable position of the tuyères in the Bessemer converter they being at the bottom. There was no quiescent zone for the regulus to settle on.

Mr. Allen (St. Helens) thought it would be better that the opinion of practical copper-smelters should be reserved to the 7th point, for E was a theoretical question, and they had no opportunity of testing the regulus made. They all knew, as a question of theory, and, indeed, of practice, that where these precious metals, as well as the baser metals, existed in copper ores, they found their way into the regulus, and not into the slag, except so far as the slag took up regulus in the way of shots.

The Chairman said he thought it was scarcely necessary to discuss F, as that might be admitted. Some of the slags were present, and were exhibited on the table, and anyone who looked at them would be pleased to see such fine specimens. G also had perhaps been sufficiently touched upon, and they might, therefore,

proceed to H. This was a point of the greatest importance; for if the quantity ofsilica sufficient to form at slag, having a proper combination,and a proper light specific gravity, could not be worked with, the process seemed to him to come to an end.

Mr. J. H. Allen (of Sheffield) thought that the assumption that 1000° Centigrade was the temperature necessary for the operation, was not justified hy experience. He thought a higher temperature was required, and, therefore, they could not use so large a proportion of incombustible material as 16 to 20 cwt. On the other hand there was such a wide margin hetween the proportion calculated and the proportion required in practice, that there was plenty of room for keeping up the temperature, and at the same time adding plenty of siliceous material to get a slag of sufficiently low specific gravity. As a matter of fact, they calculated it took ahout 4 cwt. per ton to produce the slag of a theoretical composition of 28 per cent. of silica. Therefore, between 4 cwt. and 16 cwt. there was a sufficient margin.

The Chairman asked Mr. Hollway exactly what amount of silica would give a normal slag?

Mr. Hollway said that was not the only question. The point was this, that they must have an excess of silica in order to avoid a corrosive action on the lining of the vessel, and that, by having an excess of silica, you might also add some other bases, so as to have a lighter slag and a hetter separation of it from the regulus. Consequently, although 4 cwts. might be necessary to form a ferro-silicate, they hoped to form a lighter slag, a slag which would separate more easily from the regulus below it. The specific gravity of the ferro-silica was only 4·2, and of the regulus 4·8, which was nearer than copper-smelters worked, consequently there was much greater chance of entangling the regulus with the slag. If they could make the slag 3·5, there would be a much better chance of separating it thoroughly without losing the more precious metals. Still, if the 16 cwt. were reduced to 10, it would leave plenty of margin.

The Chairman asked if the practical experiments hore out this statement?

Mr. Hollway said the experiments up to the present time had heen made in an ordinary Bessemer plant, and, working in that vessel, they could not economise the heat. A great deal passed away, aud so they had to do a great deal more work than would be uecessary in practice. In a proper apparatus the heated gases would do their work instead of passing into the air. Consequently, he had not heen able to test practically the question of how much incomhustihle matter could he added. The statement of 16 cwt. was entirely based on calculation. He would say, however, that calculations had been made by Prof. Akerman which fully corrohorated his own calculations, as would he seen hy reference to the paper.

Mr. Riley said it was calculated that 2 cwt. of sand to 10 cwt. of pyrites was ahout the proper quantity to be added.

The Chairman then invited discussion on heads "I" and "J."

M. Blanchard (who spoke in French) had noticed that in the experiments made at Penistone, the silica intended to form the slag had heen thrown into the converter in large lumps, but unmixed with the pyrites. The consequence was that the converter sometimes received several charges of silica in succession, and then several of pyrites. He thought that better results might he obtained by mixing the silica and pyrites together beforehand, and breaking them up iuto smaller pieces.

Mr. Riley said he understood M. Blanchard to say hat he thought it would be hetter to have the sand and pyrites mixed together in powder. He could not say he quite agreed with him, and he based his conclusions on the actual result. M. Blanchard was not present when they opened one converter when some of it appeared all in lumps. He then suggested that the silica should be put in in small pieces. He thought the sand should he hroken ahout the size of walnuts or eggs. Out of 20 tons of slag, he saw very few pieces of silica. There were samples on the tahle which could he inspected.

The Chairman said this was a very important question, inasmuch as the reduction of silicates of nickel and copper were somewhat difficult, and it was an important point to know whether these silicates would be found in the regulus as sulphides or not.

Mr. J. H. Allen (of Sheffield) said, as a matter of fact, nickel was less oxidisable than iron, and was not liahle to he oxidised as long as there was any iron left, and, therefore, it would pass into the regulus with the copper. It might possihly he found practicahle to use instead of sand the siliceous nickel ores, silicate of nickel and magnesium, which were now found so largely in New Caledonia, and many hundred tons of which were now lying idle in England for want of a process to work them. All the alloys containing nickel also contained copper, so that the presence of copper would he no ohjection. There was the great advantage that in this process you drove off the whole of the arsenic which was so troublesome to get rid of in the case of nickel; whether it would persist in staying if you had nickel there he would not undertake to say. There were other nickelliferous pyrites which it would be possihle to smelt with pyrites as a flux. He would also point out that the amount of material which could he added to flux the oxide of iron produced would be greatly increased when it was heated in a blast of hot sulphur, whereas practically they had heen throwing it in cold. That was really where the difference hetween the calculated and observed results arose.

The Chairman next called upon Mr. Blair to speak on the third head, and also, if he thought fit, on the fourth and fifth.

Mr. Blair said these three points appeared to involve the whole question of the plant. In the first place he would call attention to a drawing on the wall of a Bessemer plant similar to that in which the experiments were made. As Mr. Riley had pointed out, it was a great disadvantage to have the tuyères at the hottom; and going hackwards in the history of the Bessemer process, hut as he thought forward in the Hollway process, he would refer to the fixed converter as formerly used very extensively, hut now to a small extent in Sweden. There the tuyères were placed nearly horizontally along the bottom of the vessels. It was not made to tip over hy hydraulic machinery, hut the vessel was tapped when the hlowing had heen continued for the proper time. The apparatus which Mr. Hollway would require would, in his opinion, he something similar to that, hut with the tuyères a little higher. The quiescent hearth seemed an absolute necessity, because the specific gravity of the regulus when blown would cause it to sink to the hottom; the molten protosulphides would occupy the quiescent region of the furnace, hut they would gradually become oxidised, and would rise ahove the tuyères, so that in a short time the hearth would he filled with regulus. He should imagine the second row of tuyères placed a foot or so higher up would he found necessary, so that they might be used alternately. He would also propose that the lower part of the furnace be made removahle, as had been done in Germany in some of the small charcoal hlast furnaces. Instead of being supported from the foundation, as shown in the drawing, they were supported higher up, when the bottom standing on the carriage could be removed and another put in. That, it appeared to him, would get over the difficulty of the lining. A gannister lining answered very well in the Bessemer process, con-

sidering the large amount of protoxide which it had to come in contact with during its career of three months' perhaps for the lining, and one day or less for the bottoms. But Mr. Hollway might adopt a siliceous or fire-clay lining in the upper part, and in the lower he might use a lining of either bauxite or limestone. He thought all practical men must have felt a great amount of pleasure in having seen the wonderful brick Mr. Riley had recently submitted to some of them. Not only the process of manufacture, but the results obtained, were very wonderful, and he thought they indicated a step forward in the iron trade. To Mr. Hollway they would, no doubt, be invaluable, because, where molten protoxide of iron was in contact with earthy linings, he could use these basic bricks. There was a serious but not an insuperable difficulty, namely, the method of filling the furnace. There was a very ingenious application of the ordinary cup and cone shown in the large drawing, but he failed to see how ordinary cast iron could withstand the sulphur at a temperature of 500° or 600° Centigrade, but some other material might be found which would answer that purpose. There was also an immense amount of sublimates which came over which would be a difficulty. If he expected to utilise his waste heat, which he estimated at 500 degrees, it was certain that he would have to get rid of these sublimates in a very rapid manner. This was a practical question which would have to be dealt with. He had been working with a pressure of 17½ lbs. to the square inch and upwards, but he did not think he would find it at all necessary to go beyond 10 lbs., and that would lessen the estimated cost. It was self-evident that the specific gravity of these molten pyrites and regulus was less than that of the molten iron. He did not agree with one remark, that the corrosive action of the protoxide of iron could be practically avoided, when employing a siliceous lining. He did not think it could be avoided, although it would be mitigated. With regard to the quantity of coal necessary, he could only say that experience bore out the figures given in the paper. Mr. Hollway would, he thought, derive an advantage from the application of hot blast. The theory, as generally accepted, was that in a blast furnace there was no great increment of heat so far as regards the temperature on the hearth of the blast furnace, but there was a considerable elevation at the throat, so that you got off the gas at a higher sensible heat. That was not altogether an advantage, but it indicated that advantage had been gained in the reducing zone of the furnace by the assistance which the extra 500 or 1,000 degrees had communicated to the blast furnace gases which reduced the oxide of iron with far greater rapidity than a cold blast would. He would gain an advantage in the sensible heat of the escaping gases, provided he afterwards used them. He thought he, also, could coincide with the fifth statement. Unfortunately, he was not able to use his gases. They were not combustible in the first instance as in the second, they were not very hot, and he would have, therefore, to use coal for his stoves and boilers. As to the temperature of his waste gases coming from the furnace, the gas coming from furnaces of modern construction of 70 to 90 feet high, were at a temperature of 140, while in the somewhat older form you got them sometimes to 600 or 700. But there you had a combustible gas, which was utilised, which Mr. Hollway would not have. He thought his estimate of 500 degrees was too low. He talked about using a furnace 40 feet high, and that might be a convenient height, but nobody could say until it had been tried. The higher he got his furnace, the cooler his gases would be, and he might find in utilising his waste heat, subsequently, that it would pay him better to use a smaller furnace, and get off hotter gas, because the pyrites was in itself so fusible, that a great height of furnace was not necessary for the preliminary heating of it. The waste products were not referred to, but he might point out that it was a most unfortunate thing that there was so little difference between the specific gravity of the regulus and the slag he now got. The specimens on the table were perfectly well adapted for smelting in a blast furnace, and contained from 40 to 50 per cent. of metallic iron, but it was unfortunate he should be compelled to add other bases to increase the specific gravity of the slag, in order to effect a complete separation, thereby depriving the ironmasters of a very valuable bi-product. The practical difficulties of corrosion he thought would occur in almost any place where iron was used even externally, and he could assure them that in the iron trade they had had many difficulties far greater to contend with than those which he anticipated in the carrying out of this process on a large scale, and he was quite certain that those who had worked out the application of the Bessemer process, would agree with him that at the beginning it had not nearly so bright a prospect before it as this of Mr. Hollway.

Mr. Riley said in the last two experiments both the converters were worked together, and the pressure was just over 10 lbs. to the square inch. When both were blown together they could not get up so high a blast. He agreed with Mr. Blair that so high a one was not required.

Mr. Howson said—I cannot throw any light on the chemical part of the question involved in this process, but, having had the opportunity of witnessing the experiments at Penistone on two occasions, with the view of studying the mechanical difficulties, if there were any, I may be allowed to make a few remarks on this part of the subject. These experiments have convinced me, as they have convinced others, that the process can be carried on continuously, and without interruption, so long as the lining lasts. The preservation of the lining, therefore, is the first thing to be considered. From a rather long experience of blast furnaces, I conclude that a highly siliceous brick, approaching to gannister, although it may be more refractory, is at the same time more subject to scouring than one containing a large percentage of alumina. The more aluminous the brick, the less is it subject to be attacked by the oxide of iron. There can be no doubt that, in this case, when the scouring action is excessive, the most eligible material would be bauxite. A variety of other materials have been proposed for the lining, such as oxide of iron, carbonaceous bricks, &c. I am informed by Mr. Henderson that the latter, made from ground carbon mixed with magnesia, are incombustible even when submitted to a stream or air under a high temperature. It is clear that, whatever material is selected as best adapted to the purpose, it might be somewhat expensive, but it is certainly quite possible, with an inferior material, to protect it on the outside with water so as to enable it to last a very long time. I am inclined to think that a fire-brick, containing as much alumina as possible, would form a sufficiently permanent lining, provided it were protected with water, as is sometimes practised in blast furnaces. The next thing to be considered is the best form of converter. In the figure referred to, the shape is something like that of a Bessemer vessel, but instead of trunnions it is mounted on wheels, so that it can be removed from its working position and another substituted. The tuyères also, instead of being at the bottom, are placed at the sides, and the outer casing is surrounded with a water bosh. The cold pyrites is fed from a hopper into a sloping hearth, where for a time it gets the benefit of the hot gases passing away to the flues, after which it is pushed down into the converter, for which purpose a door, situated at the back, is provided. Beyond this point are the vertical

chambers for the deposit of the sublimates, and the chimney is supposed to be capable of producing draught sufficient to prevent the workmen from being inconvenienced by the leakage of sulphurous acid gas. This sort of converter is intended to deal only with five or six tons of pyrites at a time, but it is a question whether the economy of heat would not be better carried out by dealing with a much larger quantity, as is done in a blast furnace. The second diagram shows such a system where the internal capacity of the furnace will be not less than 200 tons. There can be no doubt that this method of working is the most economical and effective of any that can be devised, provided it is free from objection in other points of view. It is, of course, as yet untried, but the only dangerous possibility which is at all likely to occur, is that, through the softening and welding together of the mass of pyrites, there might be a difficulty in forcing the blast through the body of the material. It is almost certain that this action would really take place if the conditions were similar to those of a blast furnace, where the reducing action of the ascending gases tends to give to the entire mass the adhesive property of wrought iron. In this case, however, we have, first, the oxidising action of the air, and we have not to deal with carbonic oxide, but with sulphurous acid, which is not a reducing agent, and I am strongly of opinion that the intermediate stage of viscosity between solidity and absolute fluidity will be absent, and that, consequently, the stream of air will be free to ascend without hindrance. With regard to the accumulation of melted material above the tuyères ever getting too high for the pressure of the blast to overcome, this is simply a question of tapping out frequently enough to prevent it. Below the tuyères there is a well sufficiently deep to allow the richer portion of the regulus to settle down, and the tapping out will have to be timed so as to accommodate this as well as the accumulation of slag above the tuyères. The ascending gases find their exit laterally at the top, and descend by a vertical tube exactly in the same manner as in a blast furnace, and the sublimates will be collected by deposition in a long underground flue. There is only one other possible difficulty to which I would refer, viz., the corroding action of sulphurous acid and sulphur fumes (with, perhaps, traces of sulphuric acid) on cast and wrought iron. The employment of these materials should clearly be avoided as much as possible, and the upper portion of the furnace is roughly designed in accordance with this requirement, and at the same time with a view to protect the workmen from inhaling the deleterious gases The pyrites will be raised by means of the ordinary lift, and delivered on to the upper platform, from which it will be shovelled over the top of a tunnel head rising to the height of about six feet. The top of the furnace is arched over, with a number of openings ranged round its circumference. Each opening is furnished with a slide lined with a fine brick tile, so that, when the slide is withdrawn, a certain quantity of material is allowed to drop, and then the slide is closed, while any ascending gases are carried above the head of the workmen standing on the platform. This is, roughly speaking, the general principle of working which seems to promise best for the carrying out of the Hollway process, so far as the obtaining of a rich regulus, and the collection of the sublimates are concerned. In reference to the utilisation of the sulphurous acid gas, I offer no opinion, as this is a chemical question with which I am not competent to deal. The general plan of the works, which has been placed in the hands of those interested in the process, has been designed more especially as applicable to the Rio Tinto mines, as they have been described. The broken ore is delivered in the first place, and tipped into a series of bunkers at a high level. From thence it is drawn by means of shoots into small waggons, which are then lifted up to the level of the hoppers, which drop the material into the sloping banks of the converters. The system of tapping out into ladles provided for the purpose, allowing the regulus to cool, and transferring the empty ladles for a fresh tap, will be readily understood. The converters in this case are supposed to be the smaller ones before alluded to, but there is no difficulty in substituting the larger blast arrangement, which, in fact, is the more simple of the two. The blowing machinery and the boiler power will, of course, be the same in both cases.

The Chairman asked Mr. Howson if he could give an estimate of the cost of the plant?

Mr. Howson said it was given to a certain extent in the paper.

The Chairman then asked Mr. J. Fenwick Allen (St. Helens) to give his opinion as a copper-smelter.

Mr. J. F. Allen said they had had the opinion of the most scientific and experienced copper-smelter in England at the present day, Mr. Hussey Vivian, and no opinion could carry greater weight. Still, he should have much liked Mr. Vivian to have been present at Penistone last week. He desired to thank Mr. Hollway for the invitation he received, and there could be no doubt the results were very astonishing. He was not prepared to see pyrites poured in in the way he saw it, large pieces of sandstone thrown in, and then to find in a short space of time that fusion and combustion took place, that the slags were poured out, and that that a clean sharp slag was produced. There was no doubt the process was an astonishing success from a scientific stand-point; the fusion was complete, the slag seemed perfectly clean, the iron was oxidised, and the regulus settled to the bottom of the converter. Upon this point there could be no doubt whatever. They were there from 6 o'clock one morning till 4 o'clock the next, and hour after hour the process went on, the converter belching forth its flames of fire and brimstone, and then at last they saw the whole thing poured out in a thoroughly molten mass of very liquid slag, and the heavier regulus at the bottom. He thought there was very little loss of copper in vapour, for he detected none, as far as he could perceive, in the flame passing away. He did not think there would be any danger of loss of copper in the slags. He should hardly think the process was adapted for ordinary copper-smelters, because they dealt with such a variety of ores, in many cases containing very little sulphur, instead of being sulphurets they were silicates, carbonates, and oxides, and for all that large class of ores which were imported the process had no applicability whatever. He had no doubt that Mr. Vivian in his remarks had, in his mind, the variety of ores which the English copper-smelter had to deal with, but on the other hand there were ores very rich in copper, containing 30 per cent. or more, found in large quantities in districts where fuel was scarce, and where it might be advisable to bring them into a richer state than they were. Still, that was not where this process would be chiefly applicable, it was rather adapted for ores poor in copper and rich in sulphur, and found in districts where fuel was scarce. There, he thought, Mr. Hollway's process promised to be a very great success.

Mr. Galbraith said he spoke, not as a copper-smelter but as a chemist, having some little experience in the matter. In opposition to the opinion expressed in Mr. Vivian's letter, some of them had heard the opinion of a gentleman of great authority, who seemed much in favour of the process, Mr. William Henderson. It seemed to him (Mr. Galbraith) there was an intimate relation between the Welsh copper process and Mr. Hollway's, which had not been pointed out. The Welsh process, especially when treating sulphurous ores, might be divided into two parts, the first being simply the oxidation of the sulphur, or getting rid of the sulphur from the iron; and the oxidation of the iron into a silicate or a slag.

That was tapped off, and after two or three such processes they got a pretty rich regulus, the second being the reduction of the copper from the regulus. It was sometimes treated six or seven times, and Mr. Hollway's process did all at once what was done in three or four times, according to circumstances, in the Welsh process; so that his regulus would probably step in very usefully at about the third or fourth stage of the ordinary Welsh process. Moreover, it was applicable—which the Welsh processes were not—to ores containing 2 per cent., or less, of copper, which were found in enormous quantities in Spain. They could not be sent to this country, but, when treated by this process, a regulus was obtained containing, in one case, from 50 to 60 per cent. of copper, and that would be well worth shipping. With regard to stirring up the regulus by the blast, the thought struck him that the slag and regulus might be, in some way, poured into a warm mould, and kept comparatively warm for some time; in other words, the regulus might be allowed to settle slowly and that would assist in separating it.

The Chairman said perhaps Mr. Richard Taylor, who was present, might have something to say on the sixth head.

Mr. Taylor said he had not visited the Rio Tinto district, although he knew from his brother, who had been there twice, that the whole vegetatiou of the country was destroyed, and those who had been to Swansea must have seen the effect clearly enough. It would undoubtedly be a great benefit to that part of Spain if this mischief could be arrested.

Professor Graham said he knew Tharsis and the Rio Tinto districts, and there was no doubt that the burning of from three-quarters of a milliou to a million tons of ore per annum was a very great nuisance, and he should not be surprised that in a short time the Spanish Government put a stop to it; consequently it was necessary that some process should be devised, ready to take the place of the present one, which had been used since about the year 1500. With regard to the general discussion, he would only make one or two remarks as a chemist and as a member of that Society. They were very much indebted to Mr. Hollway for the admirable and valuable discussion he had elicited. They had heard the evidence of those gentlemen who had had the pleasure of witnessing the experiments, and they fully corroborated the statements made in the paper. There were, of course, considerable difficulties confronting Mr. Hollway, and he must not imagine, at the beginning of an important metallurgical process, that he would be able, in a few experiments, to find out the right way to carry on this important industry. Roughly speaking, one might say that in the Spanish pyrites there was about 2 per cent. of copper and 45 to 47 per ceut. of sulphur, and small quantities or traces of valuable metals. Mr. Hollway, at his suggestion, had struck out his remarks about lead, because practically it was so variable, and as a rule so slight, that he advised him not to take any account of it. The difficulties of course were various, some of them had beeu illustrated, and suggestions made that evening. As regards liniugs, no doubt the very valuable basic bricks introduced by Mr. Riley would be of service. Then, as regards the question of the apparatus which would be employed, there was no doubt the experiments hitherto made had been made with apparatus not adapted for such a process. They had had valuable remarks from Messrs. Allen and Mr. Blair, who gave Mr. Hollway great encouragement as regards the constructiou of the plant, and practically thero seemed to him considerable hope for this process in the future, if he continued to devote himself as he had hitherto, and if he could get others to aid him, because these were very expensive experiments, not made in small test tubes. If this were done, he had but little doubt that there would be a method devised by which the sulphur of those enormous beds in Spain would be utilised, and the copper got at a less expense than at the present time. He would not speak of the process, as brought forward that evening, for he had not had the pleasure of seeing the experiments. They had been already described, and he could not but say there were several conditions which required consideration. There seemed a necessity for intermittent action, and it would require him to consider in what way he should make the process continuous. Then there was another point on which he was afraid he could not help him at the present time, the right and economical way of utilising the sulphur. He understood that he proposed to carry out this process in Spain, and not to bring the ore to England, consequently, he would have to purify the sulphur from volatilised sulphide of arsenic, and so on, and would thus have a large quantity of sulphurous acid to deal with. These were practical points, which would no doubt give him some trouble, but as regards the main principle, that he would be able to do without coal, excepting in so far as he required it to obtain the hot blast and to overcome the 10 lbs. pressure, he had distinctly proved his point. As to the question of the balance-sheet, he did not think the experiments with the Bessemer plant would enable anyone to form an accurate idea.

Professor Abel, C.B., F.R.S., being called upon, said he came purely as a listener desiring instruction, and his desire had been fully gratified. It was a most instructive paper, and the conclusions seemed well summed up in the propositious at the close. On looking through those, which was all he had had time to do, he thought the chemical principles there enunciated were sound, and, so far as their enunciation had elicited discussion by those who had had the advantage of witnessing the experiments and going into the matters of detail, their soundness had been practically demonstrated. No doubt, like many other processes, this was one which, at first sight, seemed of very great importance, but the carrying out of it, on such a practical scale as would render it remunerative, might develop difficulties which even Mr. Hollway's sanguine temperament might not be, at first, able to meet. He himself was not qualified to point out what those difficulties might be, but would only mention one or two points which occurred to him. For example, with regard to the statement as to the quantity of sulphur expelled, and also as to how the process was to be carried on continuously, so as to render it a thoroughly paying process. The advantage of the process was not based simply on the production of a regulus, but on the utilisation of by-products and the collection of the sulphur and sulphurous acid evolved during the calcination of the pyrites.

Mr. Hollway said he had not calculated the value of the sulphurous acid gas as yet, but he hoped to do so.

Professor Abel thought that would involve considerations with reference to the plan likely to be required very different to those which would simply be involved in continuously producing the regulus. However, there appeared very great promise in the experiments already carried out, and he thought the inventor might entertain a sanguine expectation of constructing such an apparatus as would give the results he desired.

The Chairman said they must all thank Mr. Hollway for having brought forward this subject. They had all benefited by the discussion, and he trusted that he too would feel that he had gained something. It must be remembered that this question was not only a very great one, but as yet had only been half carried out experimentally. The difficulties alluded to had yet to be surmounted, and he imagined Mr. Hollway's object was not to be told that which, no doubt, he was well aware of, but to obtain opinions for or against the principles

upon which he had founded the process. As far as they had gone no great objection had been raised to them, and so far the discussion appeared favourable to the scheme.

Mr. Thomas Hughes wished to ask if the process was really a new one. He believed that Mr. Keates, the senior partner in Newton, Keates, and Co., copper smelters, Liverpool, some years ago took out a patent for this very process.

The Chairman said Mr. Allen, who was the manager of those works, was present, and could no doubt answer the question.

Mr. Allen said he did not think the discovery of Mr. Keates, to which Mr. Hughes alluded, was the same. Mr. Keates' patent was for blast applied to copper smelting, but he did not think he had the idea of oxidising the iron and fusing it into slag. It was more an application of the hot blast to a roaster furnace for the purpose of getting rid of the sulphur.

Mr. Hollway said the time had so far advanced, that he would only thank the meeting for the kind way in which they had discussed the matter.

The Chairman then proposed a vote of thanks to Mr. Hollway.

Professor Simonin (of the Sorbonne) seconded the motion, and thanked Mr. Hollway very warmly for his kindness in inviting French engineers to see his experiments. He said the process was quite as curious as that of Bessemer, and would, no doubt, be equally successful. In the beginning no one believed in the Bessemer process except Mr. Bessemer himself, but he had continued his efforts, and had realised one of the greatest successes, not only of the present age, but of all time. He was also very glad to have been invited to that meeting, and when he returned home he should tell his fellow countrymen to follow the good example he had seen that evening in discussing these practical and scientific subjects.

The vote of thanks was carried unanimously, and the meeting adjourned.

In consequence of the late hour, Mr. John Hollway was unable to reply to the different points alluded to by the various speakers, and he proposes to reply thereto in the next number of the *Journal*.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

February 19.—"Turkish Resources and their Ready Development." By J. L. Haddan, Esq., M.I.C.E., ex-Chief Engineer in the Ottoman Service. Lieut.-Gen. Sir A. B. Kemball, K.C.S.I., C.B., R.A., will preside.

Cantor Lectures.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Dwelling-houses: their Sanitary Construction and Arrangements."

Lecture I.—February 17.

Situation and Structure of House.—Drainage of soil, foundations, walls, roof, rain-water pipes, &c.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS,** John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. W. H. Corfield, "Dwelling Houses; their Sanitary Construction and Arrangements." (Lecture I.)

Royal United Service Institution, Whitehall-yard, 8½ p.m. Vice-Admiral E. Gardiner Fishbourne, "Excessive Rolling in Ships; its Causes, Consequences, and Cure." 8 p.m. 1. Resumed discussion on Mr. Hedley's two Papers; and, time permitting, 2. Mr. H. J. Castle, sen., "Contributive Value."

Institute of Surveyors, 12, Great George-street, S.W.

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 3 p.m.

Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. Rev. F. W. Holland, "The Topography of the Sinaitic Peninsula."

London Institution, Finsbury-circus, E.C., 5 p.m. Commander Francis J. Palmer, "The History of the Iron-clad."

Tues....Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture VI).

Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. James A. Longridge, "Construction of Heavy Ordnance."

Statistical, Somerset-house-terrace, Strand, W.C., 7¾ p.m. Mr. Cornelius Walford, "The Famines of the World—Past and Present." Part II.

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. E. L. Layard, "Notes on *Pachycephala icteroides*, Peale, with Description of a supposed New Species." 2. Dr. A. Günther, "Descriptions of Four New Species of Chamæleons from Madagascar." 3. Mr. Edgar A. Smith, "A Collection of Mollusca from Japan."

Royal Colonial, the "Pall Mall," 14, Regent-street, S.W., 8 p.m. Mr. John Noble, "South Africa."

Wed. ...**SOCIETY OF ARTS,** John-street, Adelphi, W.C., 8 p.m. Mr. J. L. Haddan, "Turkish Resources and their Ready Development."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. Frederick Chambers, "Diurnal Variations of the Barometric Pressure in the British Isles." 2. Mr. Frederick Bogen, "A Standard Cistern Syphon Barometer." 3. Mr. G. M. Whipple, "The Relation Existing Between the Duration of Sunshine, the Amount of Solar Radiation, and the Temperature Indicated by the Black Bulb Thermometer *in Vacuo*." 4. Mr. William B. Tripp, "Results of Meteorological Observations Made at Buenos Ayres."

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Rev. C. Collier, "The Recently-discovered Roman Villa at Itchen Abbas." 2. Mr. George Patrick, "Burleigh-house."

Society of Public Analysts, Burlington-house, Piccadilly, W., 8 p.m. Resumed Discussion on the papers read at the last meeting by Mr. E. W. T. Jones, "The Influence of the Decomposition in Butters from Age on the Specific Gravity of the Fat and the Percentage of Soluble and Insoluble Acids;" and by Mr. J. M. Milne, "Notes on the Analysis of Butter." The following papers will also be read:—1. Mr. O. Hehner, "Condensed Milk." 2. Mr. O. Hehner, "Analysis of Coffee Leaves." 3. Dr. C. A. Cameron, "The Falsifications of Milk."

Thur....Royal, Burlington-house, W., 8½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Dr. Henry Trimen, "The Genus *Oudneya*, Brown." 2. Dr. Maxwell Masters, "The Nature of the Inflorescence." 3. Mr. John Miers, "Some South American Genera of Plants of Uncertain Position."

Chemical, Burlington-house, W., 8 p.m. 1. Dr. Gladstone and Mr. Tribe, "Investigations into the Actions of Substances in the Nascent and Occluded Conditions; Hydrogen (continued)." 2. Mr. T. T. Brown, "Some Methods of Vapour Density Determination." 3. Mr. G. Attwood, "The Quantitative Blowpipe Assay of Mercury."

London Institution, Finsbury-circus, E.C., 7 p.m. Prof. F. Guthrie, "Fixed Water."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Tyndall, "Sound." (Lecture II.)

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

Royal Society Club, Willis's-rooms, St. James's, S.W., 6 p.m.

Fri ......Geological, Burlington-house, W., 1 p.m. Annual Meeting.

Royal Institution, Albemarle-street, W., 3 p.m. Weekly Meeting, 9 p.m. Prof. Roscoe, "A New Chemical Industry."

Philological, University College, W.C., 8 p.m. Mr. H. Sweet, "Contributions to Old English Phonology."

Sat.......Working Men's Club and Institute Union (at the House of the Society of Arts), 4 p.m. The Very Rev. the Dean of Westminster, "Reminiscences of the United States in Westminster Abbey."

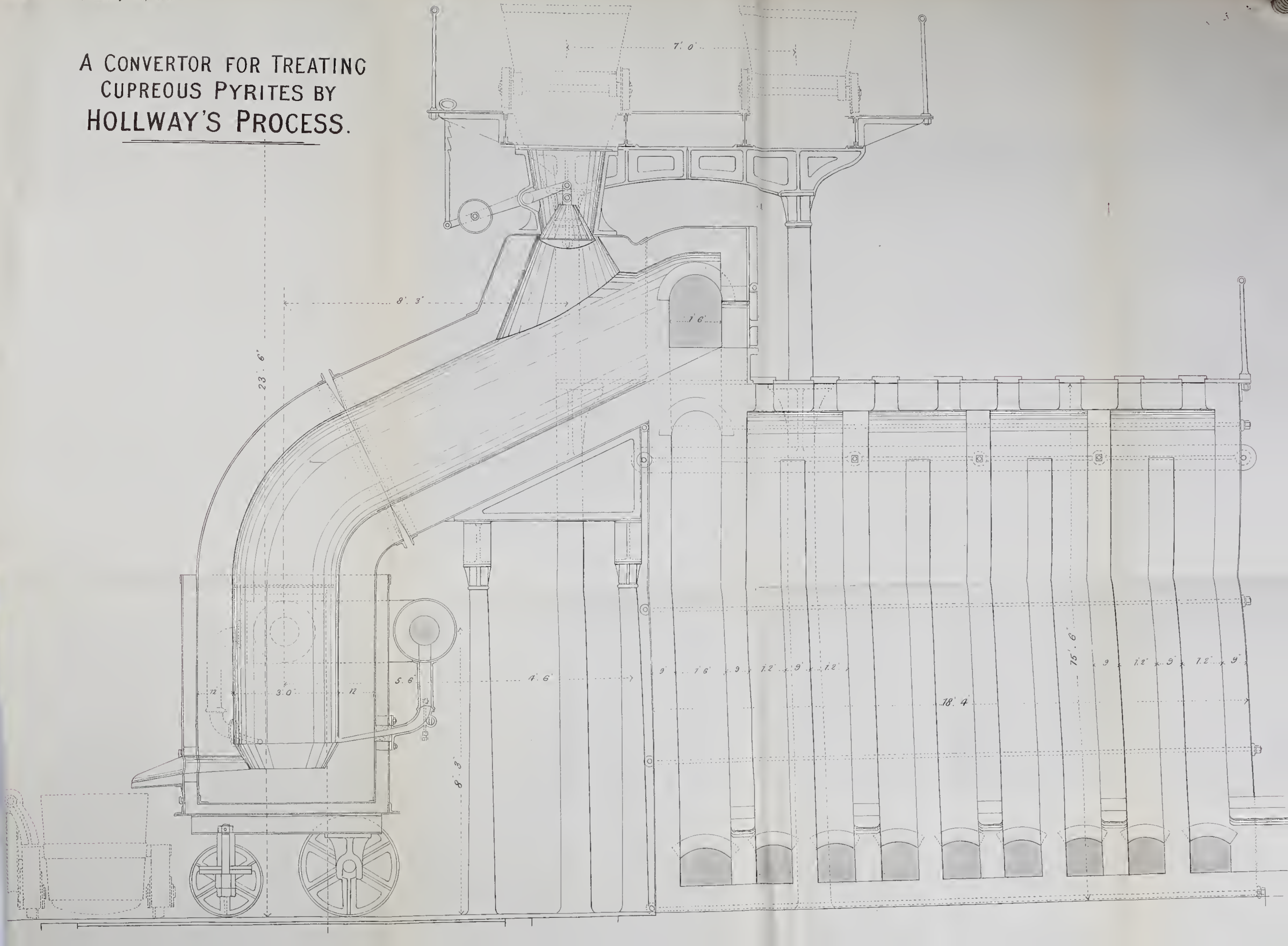
Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Dr. C. W. Siemens, "A Current Regulator." 2. Profs. Ayrton and Perry, "A New Theory of Terrestrial Magnetism." 3. Dr. A. Schuster, "The Spectrum of Lightning."

Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. Reginald W. Macan, "Lessing." (Lecture III.)

SUPPLEMENT OF THE JOURNAL OF THE
SOCIETY OF ARTS, February 14th, 1879.

A CONVERTOR FOR TREATING CUPREOUS PYRITES BY HOLLWAY'S PROCESS.



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SUPPLEMENT OF THE JOURNAL OF THE SOCIETY OF ARTS, February 14th, 1879.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,370. Vol. XXVII.

FRIDAY, FEBRUARY 21, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

COMMITTEE ON MUSICAL EXAMINATIONS AND LOCAL MUSIC SCHOOLS.

At the Meeting of the Council of the Society, held 10th February, 1879, it was resolved that a Committee be appointed to consider and report on the yearly Musical Examinations of the Society, which have been conducted since 1859 to the present time, especially with reference to the establishment of Local Music Schools and the training of teachers for elementary schools. Several noblemen and others interested in music in elementary schools were requested to act on the Committee.

SANITARY SECTION.

The Council have formed a Sanitary Section, and have appointed the following gentlemen as a Committee in charge of it:—Mr. F. A. Abel, C.B., F.R.S.; Mr. R. Brudenell Carter; Mr. E. Chadwick, C.B.; Sir Henry Cole, K.C.B.; Major-Gen. Cotton, R.E., C.S.I.; Captain Douglas Galton, C.B., F.R.S.; Mr. Coghlan McHardy; Mr. Robert Rawlinson, C.B.; Dr. B. W. Richardson, M.A., F.R.S. The Committee will meet periodically for the discussion of sanitary subjects. Communications of a suitable nature are invited.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference will be held in the Rooms of the Society of Arts, on Thursday and Friday, the 15th and 16th May, 1879, on National Water Supply, Sewage, and Health, the Right Hon. James Stansfeld, M.P., late President of the Local Government Board, in the chair, assisted by the members of the Executive Committee:—Lord Alfred Churchill (Chairman of Council); Sir Henry Cole, K.C.B.; Colonel Sir E. Du Cane, K.C.B.; Captain Douglas Galton, C.B., F.R.S.; Mr. F. A. Abel, C.B., F.R.S.; Mr. T. W. Keates; Dr. Voelcker, F.R.S.; Mr. W. Hawes, F.G.S.; Major-Gen. F. Cotton, R.E., C.S.I. Papers relating to the above subjects will be read and discussed.

Programme of Proceedings.

The Conference will meet each day at 11 a.m., and sit till 1.30, then adjourn till 2, and sit again till 5 p.m., and, if necessary, meet again at 8 p.m.

Thursday, 11 a.m.—Opening of the Proceedings by the Chairman.
Papers and Discussion.

Friday, 11 p.m.—Proceedings will be resumed.
Papers and Discussions continued.

There will be an Exhibition of Mechanical and Chemical Apparatus in connexion with Water Supply, Treatment of Sewage, and Health. All articles for exhibition must be delivered, carriage free, not later than Saturday, the 10th May, 1879. Manufacturers and others desiring to exhibit should communicate forthwith with the Secretary of the Society of Arts.

Papers on any of above heads are requested.

The object of the Conference is to discuss existing information in connexion with the results of any systems already adopted in various localities, referring to the subjects of National Water Supply, Sewage, and Health; to elicit further information thereon; and gather and publish, for the benefit of the public generally, the experience gained. The introduction and discussion of untried schemes will, therefore, not be permitted. The papers accepted for the Conference will be printed and circulated at the Meetings.

The Council of the Society of Arts have determined to offer the Gold Medal of the Society, and three silver medals, for the best suggestions, founded upon evidence already published, for dividing England and Wales into watershed districts, for the supply of pure water to the towns and villages in each district.

The suggestions must be sent in to the Society's office, on or before the 26th April, so as to be discussed at the Conference.

The details of the conditions will be issued immediately, and may be had, when ready, on application to the Secretary of the Society.

CHEMICAL SECTION.

Thursday, January 30th. Dr. C. R. A. Wright, in the chair.

The paper read was—

NOXIOUS VAPOURS EVOLVED IN CERTAIN MANUFACTURING PROCESSES, WITH SPECIAL REFERENCE TO THE REPORT OF THE LATE ROYAL COMMISSION.

By Arthur G. Phillips, F.C.S.,
Associate Royal School of Mines.

In treating of noxious vapours, a subject at present receiving a large amount of public attention, and of which the importance can scarcely be over-rated, I propose, first, to speak of alkali works only (these having been the first which were brought under legal supervision); afterwards to proceed to the consideration of the further enactments for the control of alkali and "wet" copper works, which were included under the provisions of the second Alkali Act; then to give a short sketch of the various works emitting noxious vapours which are not at present under inspection, and to point out some of the obstacles to the abatement of the nuisances caused by them. In conclusion, I purpose to review the recommendations of the Royal Commission relative to further legislation.

Prior to the year 1863, there were no special enactments for regulating the escapes of noxious vapours into the atmosphere, and it was not until the year 1862 that the increase in the number of manufactories led to an agitation on the subject. In this year a Select Committee of the House of Lords was appointed to inquire into the "injury resulting from the noxious vapours evolved in certain processes." This committee, after taking evidence on the subject, reported that they found great injury to vegetation was caused by various manufactures, the chief offenders being alkali and copper works.

With regard to the latter, the committee reported that, inasmuch as no adequate means were known for neutralising the effects of the vapours evolved, consistently with the carrying on of this branch of industry, they did not recommend that copper works should be made the subject of special legislation.

The recommendations of the committee, therefore, were confined to the mitigation of the nuisance arising from alkali works, and, in this stage of the subject, it will not be necessary to consider any vapours except those of hydrochloric or muriatic acid. The process causing the evolution of these vapours consists of the treatment of chloride of sodium, or common salt, with sulphuric acid, by which means sulphate of soda, technically known as "salt cake," is produced, a material which forms the basis of almost all the subsequent products of the works. During the conversion of the chloride into sulphate of sodium, practically the whole of the hydrochloric acid is expelled in the form of a white, pungent gas, strongly irritating if breathed, even when largely diluted with air, and exceedingly destructive to vegetation. The decomposition takes place in a large cast-iron pot fixed over a fire, and fitted with a covering arch, through which, by means of a pipe or flue, the hydrochloric acid gas is conducted to the condensers or scrubbing towers. When as much of the hydrochloric acid has been evolved as can be driven off at a low temperature, the partially decomposed product is pushed into a furnace heated to redness, in which the decomposition is completed, the remainder of the acid being evolved. The gas is conducted to the condensers together with that from the "pot," and condensation is effected by passing it through tall towers, usually made of stone, and filled loosely with coke. Down these towers or scrubbers a continuous stream of water flows, and, meeting the ascending gases, dissolves such as are soluble, more or less completely, and passes out at the bottom of the tower in the form of a concentrated solution of muriatic acid, which is afterwards employed for the manufacture of chloride of lime and other bleaching products. The non-condensible portion of the gases then passes to the chimney.

Upon the perfection of the arrangements for bringing the hydrochloric acid gas into contact with water in the scrubbers, depends the purity or otherwise of the gases escaping into the chimney.

From the year 1823, when the soda trade first assumed the position of a special manufacture in Great Britain, until the year 1863, when the first Alkali Act was passed, the only consideration influencing manufacturers to condense their hydrochloric acid was its commercial value, and as this was at that time trifling, immense volumes of it were turned into the atmosphere. In fact, until the year 1836, when the condenser at present used in every alkali works in the kingdom was invented by the late Mr. William Gossage, there were no adequate means by which condensation could be effected.

In 1863, in consequence of the recommendations of the committee referred to, an Act was passed which came into operation January 1st, 1864, by which it was enacted that—"Every alkali works shall be carried on in such a manner as to secure the condensation, to the satisfaction of the inspector, derived from his own examination or from that of a sub-inspector, of not less than 95 per cent. of the muriatic acid evolved therein."

Under this Act penalties for the contravention of its provisions were fixed, and a head inspector, Dr. Angus Smith, F.R.S., and four sub-inspectors, whose duties were to inspect the works in the following divisions, were appointed:—

1. Liverpool, including Widnes, St. Helens, Flint, Bristol, and Swansea.
2. Manchester, Eastern Lancashire, the country around Birmingham, Yorkshire, and London.
3. Newcastle-on-Tyne and neighbourhood, Middlesboro', and Seaham.
4. Glasgow, including all Scotland and Ireland.

This Act was complied with by manufacturers with but comparatively little difficulty, and that the public must have largely benefited by the operation of it is sufficiently obvious from the following information, given in the first report of the alkali inspector.

Taking ten works in the western district, it was found that, prior to 1863, they were turning out 255 tons of hydrochloric acid gas per week, equivalent to about 800 tons of strong commercial muriatic acid. Of these same works, after the passing of the Act of 1863, the inspector reports, "Seven now send out nothing," the remainder sending out but a small quantity. "So that, practically, nearly 800 tons of noxious vapours are removed from the district every week." Dr. Smith

does not, however, in this early stage of the operation of the Act, give a decided opinion as to its effect on vegetation, although he states that "a meeting of farmers in the neighbourhood decided unanimously that the gain had been great."

Subsequently, however, to 1864, the number and extent of alkali and other works emitting noxious vapours so greatly increased, that it was difficult to ascertain precisely the amount of benefit due to the operations of the Act, a considerable portion of the improvement in condensation being neutralised by the increased number of works contributing to the nuisance.

Referring to Widnes, one of the great centres of the alkali trade, Dr. Angus Smith states, that between the years 1864 and 1876, "the works increased four-fold."

The increase in this trade in the United Kingdom may be seen by a comparison of the capital invested, and the hands employed in it in the years 1862 and 1876, respectively:—

	1862.		1876.
Capital employed	£2,000,000	....	£7,000,000
Hands ,, ...	10,600	....	22,000
Annual value of finished products	2,500,000	....	6,500,000

The standard fixed by the Act of 1863 not being found perfectly satisfactory, Dr. Smith proposed a new and more stringent one, and recommended that the following addition should be made to the existing Act:—"In each cubic foot of air, smoke, or chimney gases escaping from the works into the atmosphere there shall not be contained more than one-fifth part of a grain of hydrochloric acid."

This clause was embodied in the Act of 1874, and came into force on March 1st, 1875.

It will here be seen that, besides limiting the total quantity of hydrochloric acid evolved, the Act provides for the dilution of such acid vapour as may be permitted to escape; in addition to this "wet" copper works were brought within the provisions of the Act, and restrained from turning into the atmosphere any gases containing more than one-fifth of a grain of hydrochloric acid per cubic foot.

The process known as "wet" copper extraction consists in the roasting of sulphurous ores, poor in copper, with salt, with a view to rendering the copper soluble, and its subsequent extraction by washing. The ore usually so treated consists of the residue left from pyrites, after the utilisation of the sulphur present in that mineral for the manufacture of sulphuric acid. During the roasting, the sulphur in the ore re-acts on the salt, converting a portion of it into sulphate of soda, and causing a corresponding evolution of hydrochloric acid; this acid is condensed in a similar manner to that evolved in alkali works, but as the roasting frequently takes place in open furnaces, the smoke and products of combustion pass through the condensers together with the hydrochloric acid; in order, therefore, to prevent the towers from becoming clogged with soot, it is necessary to pack them with open brickwork instead of with coke; and since the acid is much diluted with air and products of combustion, it is found somewhat difficult to bring it into sufficiently close contact with the water in the tower to determine its complete removal from the non-condensible gases.

Under the new Act the following were included as "noxious":—

Sulphuric acid.

Sulphurous acid, except that arising from coal.

Nitric acid, or other noxious oxides of nitrogen.

Sulphuretted hydrogen and chlorine.

With respect to these gases no definite standard was fixed, and it was merely enacted that every owner of works should use "the best practicable means for preventing the discharge into the atmosphere, or for rendering them harmless when discharged."

This Act, as has been before stated, came into operation on March 1st, 1875, and in order to comply with its provision as to dilution, it was found necessary for both alkali and "wet" copper works to expend large sums, estimated in the aggregate at £200,000, on increasing the number of their condensers, erecting new chimneys, and generally improving the condition of their works. At the time that this heavy expenditure was imposed upon the manufacturers, they happened to be enjoying a season of unusual prosperity, and hence were able to bear an outlay which, had it occurred at a time of depression, such as the trade is at present experiencing, would undoubtedly have had the effect of closing many of the works.

In addition to the hydrochloric acid sent off through the chimneys of works, which is easily estimated, there are often accidental escapes, due to the breakage or stoppage of pipes conducting the gas to the condensers. These pipes are often of great length, and, being exposed to changes in the weather, the joints are apt to become leaky, and then an escape takes place, the amount of which cannot be so readily ascertained as with gases passing into the chimney.

In the process of sulphuric acid making there is, also, a certain amount of sulphur acid which escapes condensation in the chambers, and, together with some small quantity of oxides of nitrogen, passes into the atmosphere. In well-regulated works, however, these escapes are exceedingly small, the quantity of sulphur acid escaping from this source not exceeding one-sixth or one-seventh of that sent off by the combustion of the coal used in the works.

Besides the vapours arising directly from alkali works, there is produced in them an immense quantity of alkali or vat waste, a material consisting chiefly of sulphide of calcium. In some districts this is carried out to sea, and then thrown overboard; in others, it is deposited upon low-lying ground, frequently to a depth of 12 or more feet, and, when acted upon by the carbonic acid of the air, gives off sulphuretted hydrogen, causing a most offensive and far-reaching smell.

This waste is also acted upon by rain water, and yields strong solutions of various sulphides of calcium, which, percolating through the ground, find their way into the streams, or drains, into which there is almost always a certain amount of weak muriatic acid discharged. This, meeting with the sulphide solutions, causes a copious evolution of sulphuretted hydrogen gas, which if not injurious to vegetation, is exceedingly prejudicial to health, and is likely to cause complaint on account of its offensive odour.

Respecting this gas, the Commission report as follows:—"We agree with the Lancashire manu-

facturers in thinking that a large part of the dissatisfaction felt by those living within the influence of their works is due to the escape of sulphuretted hydrogen. It is said to be conveyed even by a gentle wind, so as to be sensible to smell, at distances at which the more destructive gases cease to be injurious, but its presence is taken to involve all the ill consequences which muriatic or sulphuric acids can inflict."

With regard to the effects of the Acts of 1863 and 1874 in reducing the evil arising from works, the Royal Commission of 1876 reports that—"In spite of the allegations not unfrequently made by the proprietors of land that the Acts above mentioned had given them little or no relief, and that the injurious effects of the gases had increased since the Acts were passed, we have no hesitation in expressing our opinion that their operation has been beneficial, and that, even where the effects have been counteracted by a great increase of works, they have been effectual in preventing a great amount of injury and inconvenience which would otherwise have been experienced."

The Royal Commission above referred to was appointed in 1876, in consequence of an agitation, raised by landowners, whose property lay contiguous to the chief manufacturing districts, for the purpose of reporting upon the working of the existing Act, and as to the necessity or otherwise for further legislation. The Commission commenced its labours in August, 1876, the evidence first taken being that of manufacturers, landowners, agents, and farmers, relative to the damage done to land in the neighbourhood of works. Under this head a mass of evidence was heard, tending to show that in the vicinity of chemical and some other works, trees, cereals, and crops of all kinds were seriously damaged. This evidence it is impossible to controvert, and it is only necessary for anyone to journey through a neighbourhood where such manufactures are carried on in order to be convinced that surrounding such districts there is invariably a belt of country on which trees cannot exist, although grass, and other crops may still flourish. The distance to which this destructive effect extends, and the amount of damage inflicted, is a matter on which much difference of opinion exists.

Great complaints are made by landowners respecting the diminished value of land, owing to the action of chemical vapours; on this point, however, much counter-evidence has been adduced, tending to show that this decrease in value was somewhat exaggerated; that, in many cases where land had suffered injury, the loss was compensated by the enhanced value conferred upon it by the increase of population, and the consequent greater demands for building ground and for the produce of the soil.

That the value of land in some of the manufacturing districts has not fallen is shown by the evidence of Mr. James Cross, chairman of the Widnes Local Board, and Mr. Keates, of St. Helens. The former gentleman says, in 1854, the average value of land in Widnes and the adjoining townships on the Lancashire side was certainly not more than £60 per acre. In 1860, the greater part of what now constitutes the town and works of Widnes proper was a salt marsh, and was bought from the Duchy at from £30 to £40 per acre. The lowest value of any land now within half a mile of Widnes Post-office is £1,200 per acre. Mr. Cross adds that there is no doubt that land within four or five miles of Widnes has also become enhanced in value, and gives instances of land lying two and a half to three and a half miles distant which, although in 1854 worth only some £60 per acre, has since realised from £300 to £600.

Mr. Keates, referring to St. Helens, says that he bought the land, on which his works were originally built, at about £45 per acre, and he now estimates the value at £400 per acre. In another case he purchased land for works at £60 per acre, and, some few years back, requiring room for extension, had to pay for it at the rate of £900 per acre. This last case, although of some use in showing the increased value of property close to works, is obviously inapplicable to that lying at a distance, and which may be near enough to receive injury without being sufficiently close to benefit by the presence of works, except in so far as increased population tends to give a better market for its produce.

It should be noted, however, that in some cases the very landowners who complain most of the damage done to their property have themselves leased portions of their estates, at enormous rentals, to alkali manufacturers.

The fact that wherever a number of chemical or certain other works are collected the land, in the vicinity is more or less damaged for agricultural purposes, being sufficiently established, the labours of the Commission were directed to the consideration of the various manufactures causing an evolution of noxious vapours not yet under legal control. The chief of these are as follows:—

Sulphuric acid works....	Evolving	acids of sulphur and nitrogen.
Copper smelting works ..	,,	sulphur acids.
Lead ,, ,,	,,	sulphur acids and lead fumes.
Glass works.............	,,	sulphur acids.
Coke ovens..............	,,	sulphur acids and smoke.
Chemical manure works	,,	sulphur acids and various organic odours.
Salt works..............	,,	sulphur acids and smoke.
Cement works	,,	organic odours.
Potteries................	,,	hydrochloric acid.
Tar distilleries..........	,,	sulphuretted hydrogen.

From the above list it will be seen that the destructive agent escaping from the majority of these works consists of sulphur acids, the most general being sulphurous acid.

It must not be forgotten that the mere burning of coal, especially of inferior qualities, gives rise to the evolution of sulphurous acid in considerable quantities, and that the large amount of fuel burnt in manufacturing districts would probably be sufficient to account for the damage to vegetation, even if no noxious vapours were evolved from manufacturing processes themselves.

In his evidence as to the relative quantities of sulphur evolved from the combustion of coal, as compared with that due to the escapes from sulphuric acid works, Dr. Angus Smith, states that,

taking the quantity of coal burnt in the whole country, for all purposes, at 100,000,000 tons per annum, the quantity of sulphur turned into the atmosphere by its combustion would amount to about 1,000,000 tons, whereas the total quantity of sulphur used in the manufacture of sulphuric acid does not amount to more than 266,000 tons per annum, of which there is evidence to show that not more than two per cent. is permitted to escape.

Respecting copper smelting works, evidence was adduced to show that, although by conducting certain of the operations in improved apparatus, from 30 to 40 per cent. of the sulphur evolved could be condensed, the remaining 60 to 70 per cent. must of necessity pass into the atmosphere, no means having yet been discovered by which sulphurous acid escaping at very high temperatures can be condensed. The retention of even the 30 to 40 per cent. of sulphur above referred to necessitates the erection, at a great expense, of apparatus for the manufacture of sulphuric acid, and this improvement appears only to have been adopted by a few firms, including Messrs. Vivian, of Swansea; Messrs. Newton, Keates, and Co., and one other firm at St. Helens.

The sulphurous acid evolved from lead works is subject to the same obstacles to condensation as that from copper works, and it may be considered, in the present state of our knowledge, impossible to prevent its escape. For the retention of lead fumes, numberless inventions have been tried, and large sums expended in efforts to render the condensation of the fumes more perfect. None of these have, I believe, met with success, and at the present time the means recognised as most effective consists in passing the smoke through very long and tortuous flues, in which the fume is mechanically deposited; the employment of the best means for this purpose scarcely requires to be forced on manufacturers, since their own interest is sufficient to urge them to use the most perfect method for saving so valuable a material.

From glass works a certain amount of sulphurous acid is evolved by the fusion of a mixture consisting of sand, lime, sodium sulphate, and charcoal. During the fusion, the whole of the sulphur which is present in the sodium sulphate is evolved in the form of sulphurous acid, the alkali entering into combination with the silica supplied by the sand. The process of fusion is a very slow one, occupying 12 hours, during the whole of which time the evolution of sulphurous acid is taking place; the gas so generated mixes directly with the products of combustion of the coal employed in the furnace, and is thus largely diluted before its escape into the air. The high temperature of the gases escaping from these furnaces, coupled with the diluted condition of the sulphurous acid, renders it impossible to condense the latter.

The amount of sulphur acids evolved from sodium sulphate in glass making is usually less than the quantity given off by the combustion of the pyrites present in the coal employed, and in some cases does not amount to more than one half of that quantity. Experiments made by one glass manufacturer show that there is not a greater proportion of this acid in the gases escaping from his melting furnaces than in those from his boilers. It is evident, therefore, that the evolution of sulphurous acid from works of this character cannot be avoided, until some process has been discovered by which the acid evolved by the combustion of coal used can be condensed.

The damage from coke ovens arises from heat, smoke, and sulphur compounds, which, in the old form known as the "beehive" oven, escape at a height of 10 to 15 feet from the ground, causing much damage in the immediate vicinity. The only remedy for this evil appears to be the adoption of improved apparatus, by means of which the hydrocarbons evolved in the process of coking are more completely burned, the injury caused by the escape of the products of combustion being mitigated by the employment of high chimneys, so as to ensure their dilution before coming into contact with vegetation.

The escapes of noxious vapours from chemical manure works are due to the manufacture of sulphuric acid, and, as in alkali works, consist of sulphur acids, with some oxides of nitrogen; these works will, therefore, as far as such gases are concerned, probably be placed under the same restrictions as alkali works. In addition, they frequently cause a nuisance by the treatment of animal refuse and other organic matter, from which an offensive and far-reaching odour is given off. Although this has probably no injurious action on vegetation, it is exceedingly objectionable to persons living in the neighbourhood. I am not, however, aware that any adequate means for its prevention have been devised.

In the neighbourhood of salt works, in which the salt is obtained by the evaporation of brine from saline springs, considerable damage is caused by sulphurous acid from the coal, by black smoke, and by particles of salt carried off in the steam. The evidence brought before the Commission showed that, although fines had been repeatedly inflicted on the manufacturers by the local authorities for permitting black smoke to escape, no improvement had taken place; and the general opinion of the manufacturers was, that any attempt at legislative interference would have the effect of driving the trade from the districts, in which it has been carried on for centuries. The magnitude of this trade may be estimated, from the fact that the present production of salt in England amounts to 2,750,000 tons per annum.

The process of cement making is one producing vapours which, although probably rather offensive than injurious, are frequently the subject of complaint. The process, as carried on in various works in the neighbourhood of London, consists in the mixing of chalk and Medway clay with water. This mixture is dried and burnt with coke, in kilns, whereby it is converted into half-fused masses, which, after grinding, constitute cement. The offensive vapours appear to be organic, chiefly due to imperfect combustion of some of the materials employed, and might be, to some extent, prevented by the use of improved apparatus.

Although potteries in which the process of salt-glazing is carried on were brought under the notice of the Royal Commission, the damage caused by such works must be comparatively trifling, and arise from the escape of hydrochloric acid from the salt used in the glazing process.

On the passing of the Act of 1863, these works were not included under the Alkali Act, owing to there being at that time no means known by which

the hydrochloric acid evolved could be condensed. Experiments made since that date appear, in the opinion of the alkali inspector, to show that with improved appliances the escape of the acid can be prevented, and that potteries might be placed under the same restrictions as alkali works.

The Royal Commission, after taking evidence of a most complete and voluminous kind, as may be seen from the minutes of evidence, recommended certain amendments of the existing Alkali Act.

Under this head it is suggested that a definite standard of escape be fixed for sulphur and nitrogen acids.

According to this proposition, sulphuric acid works would be placed under inspection; the escape of more than one grain of sulphur in the form of any of its acids, or of more than half a grain of nitrogen in the form of any of its acids, being made an offence under the Act.

Against the adoption of this clause it may be urged that, although in well-conducted works the escape of sulphur acids, on the average, is considerably less than the proposed standard, there are times, such as when kilns are first lighted, when for a short period it would be impossible to keep within the prescribed limits. On this ground, therefore, it seems more desirable that some discretionary powers should rest with the inspector than that a fixed standard should be insisted upon. The amount of nitrogen in the form of its acids is probably always much below the required standard of half a grain per cubic foot in all works where absorbing towers are employed.

In connection with alkali works, it is further proposed that the deposit of alkali waste so as to cause a nuisance be considered an offence under the Act. This recommendation, if properly carried out, cannot fail in producing much benefit by the removal of a gas which, as before stated, is the cause of many of the complaints made.

The Royal Commission further recommend that chemical works, arsenic works, cement works, cobalt works, copper works, galvanising works, glass works, lead works, nickel works, potteries where the salt-glazing process is carried on, salt works, spelter works, tin-plate works, or works for the manufacture of dyes from coal tar derivatives, be placed under the supervision of inspectors appointed under the Act, who should have a power of entry and of inspection, and that their proceedings should be reported annually to the Local Government Board.

That with respect to any of the above-mentioned works, the Local Government Board be empowered, from time to time, to fix by provisional order, to be confirmed by Parliament, a standard of escape, or to require the adoption of the best practicable means for preventing escapes.

This suggestion, that a standard for any particular manufacture should be fixed from time to time, has obviously many advantages. If this were adopted, works not at present under legal control would at first merely be subject to inspection. After the expiration of twelve months, the inspector's report would show what amount of noxious vapour was discharged from the best-conducted works of any particular class, and this amount might be made the maximum escape permitted by law. This would lead to all works being carried on as well as possible under the existing state of knowledge, and, as soon as any improvement tending to the more complete prevention of noxious vapour was discovered, the standard might be raised. The standard being thus based upon actual results, there could be no fear of its being fixed so high as to render it impossible for manufacturers to comply with it.

The question as to whether the inspection of works shall be central, as at present, or whether the inspectors shall be under the control of local authority, is one of the utmost importance, and was fully laid before the Royal Commission.

The manufacturers are unanimously in favour of an extension of the present system of central inspection, urging that under it the inspectors, who are gentlemen of scientific education, are frequently able to make valuable suggestions as to improvements in methods of condensation, and being under the control of a head inspector, there is far more probability of the law being carried out with an equal degree of stringency in the different manufacturing districts, than would be the case if the inspection was under the control of a local authority. composed, perhaps, in some cases almost entirely of manufacturers, and in others almost exclusively of representatives of agricultural interests.

In the first case, there would be danger of the law becoming a dead letter through the laxity with which it might be administered; while in the second it would be enforced with a severity fatal to the carrying on of manufacturing industries.

Referring to this subject, the Commissioners report, "That an equal standard of inspection can easily be maintained by a chief-inspector dealing with subordinates appointed by Government and independent of local control; it is doubtful whether it could be preserved among officers appointed and paid by local authorities and subject to local influences." Further, that "there is reason to fear that manufacturers would submit with more reluctance to local than central inspection; they have some confidence that a Government inspector will not press upon them with extreme severity, nor hold them responsible for consequences inseparable from their manufacturing processes. however carefully conducted. These trades cannot be carried on with absolute innocuousness, and, therefore, occasional forbearance will be as necessary a quality in an inspector as vigilance or firmness, and more likely to be found in a Government officer than in a local officer."

The very large extent of the districts assigned to the different sub-inspectors will probably, when a new Act (including many works not at present inspected) has been passed, necessitate an increase in the number of inspectors. It is to be hoped that these will be placed under the control of the present inspectors, who, since the passing of the first Alkali Act, have had ample time to make themselves acquainted with the works in their several districts.

The condition of the existing law as to recovery of damages for injury caused by manufactories was also brought prominently under the notice of the Commissioners. The complaint made is that when injury is caused to crops by the emanation from any works, the person whose property is so injured can obtain no redress, unless he can point out and trace home the damage to some particular

offender; this is stated to be absolutely impossible where works are thickly congregated together. As a remedy for this, Mr. F. S. Reilly has drawn up a scheme in which he proposes that "where there are collections of works contributing to damage, a district should be formed by the Local Government Board, within which the owners of all works emitting damaging vapours should be registered and be collectively liable."

A person seeking to recover compensation for damage caused by any works within the district would be entitled to bring his action against a nominal defendant, on behalf of all the registered proprietors, and to have execution on his judgment against any individual owner. "If the judgment were not satisfied out of a common fund established by such owners, the individual against whom execution was had would be entitled to contributions from the other owners;" the apportionment of damage being left entirely with the manufacturers themselves. The objections of the manufacturers to such a scheme are stated in a memorial recently presented to Mr. Sclater-Booth, President of the Local Government Board, by a deputation of alkali manufacturers, in which the latter urge that "they object stongly to a compulsory partnership being established between them and all other persons sending smoke of any kind into the atmosphere, which would do away with one of the strongest incentives to careful management, as under it a manufacturer who is careful to minimise the amount of mischief done would be put on the same level as another less skilful or less scrupulous, or unable, from want of means, to make the expenditure necessary to keep his works in good order."

It is further pointed out that, should such a collective liability be established, not only every works causing an evolution of sulphurous acid, from the combustion of coal or otherwise, but even every private house, must in equity be joined in that responsibility. The memorial calls attention to the recommendation of the Commissioners that exceptional legislation should not be resorted to until the failure of the existing general law has been established. That the present law is not insufficient appears to be shown by the fact that, out of 43 actions for damages brought in the county courts of Lancashire and Cheshire, five were withdrawn by the plaintiffs, seven removed to superior courts, and that, in 27 out of the 31 cases actually heard, the plaintiffs recovered damages.

Had the landowners been content to have awaited the result of the recommendations contained in the report of the Royal Commission, the manufacturers would probably have been equally satisfied to have done so. Almost immediately after the publication of the report, however, meetings were held by the various associations for controlling the escape of noxious vapours, the result being that a deputation of gentlemen, representing agricultural interests, waited upon the President of the Local Government Board, in November last, with a view to getting the collective liability, and other clauses rejected by the Royal Commission, inserted in the new Act.

This action on the part of the landowners rendered it imperative that the manufacturers should draw up a counter-memorial, in order, if possible, to prevent the imposition upon them of legal restrictions which could scarcely fail to prove fatal to their industries.

On the occasion of a deputation of landowners waiting on Mr. Sclater-Booth, a remark was made by one of its members, having property in the neighbourhood of Widnes, to the effect that, "If this dire evil could not be grappled with, the neighbourhood would be devoid of county gentlemen," and he "could not fancy a worse evil to befal a community than such a disaster."

This can scarcely be said to under-estimate the value of county gentlemen, and seems to savour somewhat of the sentiment:—

> "Let wealth and commerce, laws and learning die,
> But leave us still our old nobility."

Whether the occurrence of the catastrophe prophesied would be regarded as a greater calamity than the extinction of industries by which thousands of persons are enabled to gain a livelihood, is a matter on which a difference of opinion may fairly be supposed to exist. It must not be forgotten that land occupied by manufactories gives employment to at least one hundred times as many men as it would if devoted to agriculture.

The increase in the population of Widnes during the last thirty-eight years may be taken as an example of this fact.

In the year 1841, the inhabitants numbered 2,200, at the present time the number is somewhat over 20,000; almost all directly or indirectly supported by chemical works. Had this district remained purely agricultural, there is no reason to suppose that it would have afforded employment at the present day to a man more than it did in 1841.

It, therefore, behoves our legislators, whilst striving to prevent damage from such industries, to avoid, as far as practicable, so restricting them as to drive the trade to other countries, and so deprive a large proportion of our manufacturing population of employment.

DISCUSSION.

Mr. John Spiller said this subject was one to which he had paid considerable attention for some years past. In the main Mr. Phillips' views coincided with his own opinion, but there were points upon which, with all due deference, he thought there was room for considering whether the same results could not be brought about by other means. The greater part of the paper was taken almost verbatim from the report of the Royal Commission; but it was Mr. Phillips' own opinions which would be interesting to the meeting. It was evident that Dr. Angus Smith and the four sub-inspectors were doing their utmost, but were still quite inadequate to accomplish the tremendous amount of work imposed upon them. The very limits of the different districts were enough to show this. It should be remembered also that this work could not be properly carried on during the usual recognised office hours; inspection should be done as much after dark as during the day, for it was a well-known fact that certain disagreeable operations, such, for instance, as the opening of a chlorine chamber, in order to abstract the bleaching powder, were, sometimes at least, performed at night, and he certainly thought the evidence tended to show that it was especially at night that the bulk of the damage complained of was done. It was amusing to notice that the fourth sub-inspector's district included all Scotland and Ireland, so that it

was perfectly evident that inspection in this district must be, to a considerable extent, a dead letter. He thought it was a hopeful sign in this matter of chemical nuisance that within ten years it should be possible, so far to diminish the amount of hydrochloric acid thrown off from alkali works, as to bring it to the comparatively low limit of $\frac{1}{5}$ grain per cubic foot of gas or air passing off. This limit was so low that, if it were adhered to in all cases, barring accidents and escapes, there was every reason to believe that the quantity of acid fumes would do no damage to vegetation. But the melancholy fact remained that occasionally accidents happened to machinery and plant; a pump might get choked, or the supply of water stopped in some other way, and consequently the water tower was no longer efficient, and the gas escaped into the atmosphere. Not long ago the whole chimney stack of a large works tumbled down altogether, and of course a large quantity of acid fumes escaped. These accidents, and such things as the opening of chlorine chambers, must be controlled, and in order to do so a much larger staff of inspectors must be maintained. In the last report of the Royal Commission it was proposed to extend the effect of the Alkali Act to other works, but it would be desirable to get at some more definite basis of inspection than was contemplated by that Act. The gases to be objected to were specified thus—the escape of more than one grain of sulphur in the form of any of its acids in one cubic foot of the exit gas was to be made an offence under the Act. In the next paragraph it was said that the escape of more than $\frac{1}{2}$ grain of nitrogen in the form of any nitrous acids was to be objected to. These things could easily be ascertained; but there were other points on which great differences of opinion existed, and it would be impossible for any two inspectors to arrive at exactly the same conclusion. They were agreed on a number of chemical vapours which were known to be injurious, namely, the acids of sulphur, of nitrogen, sulphuretted hydrogen, and chlorine; these were now to be suppressed, and with regard to them it was prescribed that the best practical means of suppressing or condensing them was to be resorted to. The point of greatest importance seemed to him to be that the inspectors should be careful to draw a line between the injurious properties of these several compounds. It was well known that chlorine was much more destructive to vegetation than sulphuretted hydrogen, and if the same standard were taken in all these gases, there would be mixed up in the same category quantities of material which would do very different amounts of damage. Sulphuretted hydrogen, for instance, was remarkable for the very little deleterious influence it had on vegetable growth. The grand point, however—to which Dr. Angus Smith himself had referred in his report—was the immense quantities of sulphurous acid produced by the combustion of coal. Some interesting evidence on this point was given in the Commissioners' report. For instance, Mr. Carey referred to a case where six times as much sulphurous acid was given off from the combustion of the coal as in the process of the manufacture complained of. Dr. Angus Smith, also, mentioned this point, and he appeared to believe in the ultimate discovery of a means of condensing it in large works, but not in private houses. He would suggest that this very important point should be attended to, and he thought the sulphurous acid produced by the combustion of coal might be absorbed, or neutralised, by black oxide of manganese placed somewhere between the fire and the chimney. It would be converted into soluble sulphate of manganese, for which there was now a demand for painters' dryers, and it was always used instead of the common lead dryers when zinc white was employed. It was well known to chemists that, in their laboratories, it wa usual to introduce black oxide of manganese, or plumbic peroxide, in order to absorb the sulphurous acid given off from the combustion of organic compounds containing sulphur.

Mr. Frederick Braby said that, England being essentially a manufacturing country, this subject was of immense importance, because the value of land would be very much less if the population were decreased by any serious interference with its manufacturing industries. They had increasing difficulties to contend with in the competition with foreign countries, some of which possessed certain advantages, so that he thought some tenderness was necessary in dealing with this subject. That view seemed to be held by the Royal Commissioners as well as by the reader of the paper. The whole population of this country would starve in six months if provisions were not imported from abroad, and this could only be done by sending something abroad in exchange. Mr. Phillips said there was no sufficiently well known remedy for sulphurous acid, and it seemed to him a hardship that manufacturers should be compelled to prevent the exit of this gas, unless those compelling them were able to suggest some remedy. If a remedy could be suggested, then a nuisance might be prevented, even at considerable expense; but, unless this could be done, the effect would simply be to drive the industry out of the country. With reference to the nuisance and smoke from coke ovens, they were most numerous in the neighbourhood of iron-works, and it occurred to him that the carbonic acid gas might be led along a horizontal tube containing a layer of incandescent coke, by which means the CO_2 would be converted into $2CO$, and it might then be led into the aspirator of the blowing machine of a hot blast, and thus a hot blast containing carbonic oxide would be driven into the blast furnace, instead of oxygen and nitrogen as at present. A certain amount of sulphurous acid also would come from the coke, but he thought that would be compensated for by the elimination, or nearly so, of the great quantity of waste nitrogen which was now drawn into the furnace. The carbonic acid gas which came from the lime-kilns in the immediate neighbourhood of the ironworks might be dealt with in the same way, and converted into carbonic oxide, which, in combining with another atom of oxygen, gave an enormous amount of heat.

Mr. Riley thought these last suggestions very impracticable, and did not see how they were to be carried out. Neither did he think Mr. Spiller's suggestion for absorbing sulphurous acid by peroxide of manganese could be carried out. The only thing he could suggest to absorb the sulphurous acid was lime, and he did that with a great deal of diffidence. The quantity of sulphur driven off from the burning of coal in such towns for instance, as Leeds, was enormous. There was in the neighbourhood of that town a bed of coal known as the Black bed, which contained over 3per cent. of sulphur, and the quantity of sulphurous acid thrown into the atmosphere was far greater than that from any works in the country. To prove this, he might state that he lived in a house in Leeds, which was slated with thin slabs of magnesian limestone, and he found on the upper surface an immense quantity of crystals of sulphate of magnesia, a quarter of an inch thick, all over the surface, which could be scraped off in any quantity. Manganese was such a valuable product that he did not think its use would be practicable; lime was cheap, and perfectly separated the sulphur, but he saw great practical difficulties even in using that. If coal were much dearer it would be necessary to adopt more perfect means of collecting waste products, as was done in France.

Mr. J. A. Phillips asked Mr. Spiller if it were usual to pack bleaching powder at night; he never heard of its being done, and it would much increase the cost.

Mr. Spiller said the operation of packing took a considerable time if the chambers were large, and the door had to remain open for some time before the men could enter. Then it took a considerable time to collect

the chloride of lime from off the shelves, and pack the barrels. He knew as a fact that the chambers had sometimes been opened at night.

Mr. J. A. Phillips said, as far as he knew, the operation was always carried on by daylight. The gas remaining in one chamber ought to be drawn into another, by means of a chimney, before the packing in the first was commenced. There was, of course, a breakdown now and then. Although one factory might be established in a neighbourhood, and, if all these precautions were taken, it might go on working for many years without the vegetation being affected, he was pretty sure, as far as his experience went, that if 20, 30, or 40 works were congregated together, the gases escaping from each would, in the aggregate, be very injurious. It was impossible to prevent leakages, and, with a large number of works, there would be almost sure to be a leak from one of them every day.

Mr. Spiller said his idea was to use manganic peroxide for the purpose of manufacturing sulphate of manganese, which, at present, sold at a far higher price than oxide of manganese, from which it was made.

Mr. Riley said this was getting quite out of the commercial view of the question. His impression was that about 12,000 tons of black oxide of manganese came into the market yearly. If you brought 10,000 tons more, the price would go down to about half, but it would take all the manganese in the world to absorb all the sulphurous acid given off in the daily combustion of coal.

The Chairman thought there would be a great difficulty in applying either lime or manganese where the products of combustion escaped in a heated state, because whatever appliance was used it would necessarily interfere with the draught. There were many points in this paper which were especially interesting to him, having some years ago been connected with the alkali trade as a chemist, and knowing the district referred to in the report, and the particular estate, upon the damage to which so much stress was laid, in the neighbourhood of Runcorn. One important point with regard to the testing of the noxious gas was the recommendation of the Commission that the exit gases should be tested as they escaped from the plant itself, not from the top of the chimney; that they should not be diluted with air drawn into the chimney purposely, or with the products of combustion from the boilers or furnaces. The effect of a small amount of sulphurous acid, although marked when it was diluted with a certain amount of air, would become very much less when diluted with a larger quantity; and hence it would seem, at first sight, fairer to the manufacturer to examine the total quantity of gas that he discharged into the air, and to put a limit to that, and not to the more concentrated substances which escaped from a portion of his plant into the chimney, there becoming largely diluted. The serious effect produced by even very minute quantities of sulphurous acid in the air might be illustrated without going far out of London. On the Houses of Parliament you might notice the corrosive effects of the sulphurous acid in the air, on the magnesian limestone of which they were built. In connection with nuisance cases, he had frequently had to determine the amount of sulphur compounds in the air both in London and outside it, and amongst the means used he had examined the deposits on trees and vegetation. The amount of sulphates found in the dust scraped from a particular kind of tree in Kensington-gardens, as compared with a similar tree in Epping-forest or Richmond-park was very marked. Taking the average of 12 experiments, the amount of sulphates in the dust from a tree in Kensington-gardens would be 10 or 20 times as much as that found in similar dust from a tree a few miles out of town, and this again would be greater than in dust on trees in purely country districts. It might be argued that, inasmuch as this dust generally showed no reaction to litmus, that a large amount of sulphurous acid in the air had become neutralised, and rendered practically harmless, by the ammonia arising from the decomposition of the organic matter of vegetation and similar matters. With reference to the escape of vapours at night by the carelessness of workmen, he feared there was some truth in the allegation. Methods for the automatic testing of such fumes of gas as escaped by a chimney had been proposed of late years, and one particularly successful method had been invented by Mr. Mactear, for application to vitriol chambers, to see that they were in working order, but it was capable, no doubt, of other applications. To one of the classes of works which the Commissioners recommended should be placed under inspection, namely, tar distilleries, it was quite possible to apply an automatic arrangement, to detect whether sulphuretted hydrogen escaped from purifiers or condensers. The Commissioners recommended that not more than one grain of sulphur, in the form of sulphurous acid, per cubic foot, should be allowed to be discharged, but he did not think it would be practicable to keep within that limit in tar distilleries, where the sulphuretted hydrogen was consumed by passing through a fire; whilst the recovery of the sulphur by peroxide of iron and similar processes had not proved to be easily carried out so as to be a commercial success. In the process of making coal into coke, especially of the kind used for iron furnaces, something like half the sulphur present in the coal was expelled, and this sulphur escaped with the products of combustion into the air, partially utilised (whether or not by making them heat boilers on the road), in the shape of SO_2, which gradually became oxidised in the air into sulphuric acid, and interfered seriously with vegetation. With reference to this point, he might mention that the law courts were not always so inimical to the producer of noxious vapours as was sometimes supposed. He recollected rather an important case in the North of England, where a landed proprietor sought an injunction against a company which manufactured coke very largely close to his estate, on the ground that great injury was done to the trees and vegetation. In the course of the action, scientific evidence was produced, showing that so many thousand tons of coal per annum were carbonised; that this coal contained, on an average, 1 per cent. of sulphur; that half of it escaped into the air; and that, therefore, a quantity of sulphur, equal to so many thousand tons of oil of vitriol, was thrown into the air yearly. The remark of the Master of the Rolls, on perusing this evidence, was that, if he believed one-hundredth part of that quantity of sulphuric acid was actually evolved, he would grant the injunction without hearing further evidence; he did not, however, grant the injunction, although the facts and figures were there clearly before him; so that, in that case, the manufacturer could hardly say he had been unduly pressed on the legal side. He might refer to one case, of a tar distillery, which, though not mentioned by Mr. Phillips, was referred to in the Commissioners' report —a case where the manufacture of sulphuric acid, acetic acid, and sulphate of ammonia were all carried on on the same premises. He had occasion, in reference to that case, to devise a system for automatically testing the gas which escaped from the sulphuretted hydrogen consumers, to see if they were attended to carefully by night as well as by the day, because one of the greatest difficulties in carrying out the destruction of the sulphuretted hydrogen produced from gas liquor was that the workmen were apt to be inattentive to the fire at night, and let it go down, or not condense the steam thoroughly, so that the fire was put out, and a large amount of sulphuretted hydrogen escaped. By the application of a method which was pretty much the same as Mactear's automatic process, he got a current of air sucked continuously from the chimney, for a considerable number of hours, and found it quite possible

to get conclusive evidence on this point; but the kind of evidence which was frequently relied on he found was often illusory in a case of that sort. If an ordinary acetate of lead paper were exposed to a gas which contained a trace of sulphuretted hydrogen, it became blackened; but if this paper were afterwards submitted to a current of heated air, or to products of combustion which contained sulphurous acid, the blackening was considerably diminished, and after a certain time the blackening was wholly bleached; so that you might have a considerable escape of sulphuretted hydrogen during a part of the night, and yet the tell-tale paper would not reveal it when examined in the morning, because the blackening would have been removed. This could be guarded against by using a different absorbent. If a tartar emetic solution were used, the least trace of sulphuretted hydrogen produced the accustomed precipitate, and this was not redissolved, even by bubbling through it gases containing sulphurous acid. Similar appliances were quite practicable with reference to many other gases. With regard to certain escapes from alkali works, he might notice that the total escape of hydrochloric acid, for instance, could not always be obtained by simply determining how much was present in the gas escaping from the tower, &c., into the chimney, because very frequently a considerable quantity either leaked out through the pipes or escaped from the salt cake when the charge was drawn. Of course this could be drawn into a covered receptacle, so that the vapours might be drawn into the chimney, but this was sometimes not done, and a considerable escape took place in this way, more, he believed, than escaped condensation in a well-constructed water tower. The same remark applied to various other manufactures, as for, instance, that of sulphuric acid. There were always apt to be cracks and crevices in the pipes which conveyed the sulphurous acid, and also in the lead chambers themselves, and though there might be an in-draught, there would always be a certain amount of leakage. He failed to see how they could determine the actual quantity which escaped in this way not only at any given moment, but on an average over a considerable time; it was to these occasional escapes that a great deal of the mischief to vegetation might be attributed. He took it the damage done in these cases did not arise so much from the absolute quantity of noxious material escaping as from its comparative concentration. In conclusion, he would repeat that he thought the recommendation that the gases escaping should be tested as they passed from the exit flue into the chimneys, and not at the top of the chimneys should be abrogated, because it might cause the Act to press more heavily on manufacturers than was wholly necessary.

Mr. A. G. Phillips, in reply, said he agreed with Mr. Spiller as to the difficulty of the inspectors, even if their number were increased, being able in a large district to detect every escape of vapour. He might inform him, however, that it was the practice for them to make an inspection at night, unexpectedly, if they had reason to believe that an escape was taking place. The control of accidental escapes, such as from breakage of pipes, was exceedingly difficult, because at the present time there was no standard fixed for it, and unless the inspector had some discretionary power given to him to enforce the carrying on of the works in the best practicable manner, it was scarcely possible for him, under the present Act, to interfere in any way with an accidental escape. No doubt, it was an advantage, in some respects, to have a definite standard fixed, such as one grain per cubic foot of sulphur acids and half a grain of nitrogen, but it was well known to manufacturers that, at certain times, an escape of a larger amount than one grain of sulphur acids was unavoidable. At the same time, under ordinary circumstances, even if the sample were taken from a small flue, about 2 ft. square, it was usually found that the gas was actually freer from sulphurous acid than the gas from coal as ordinarily burnt; therefore, it had been proposed that the inspector should not take any particular sample, but should be allowed to take the average of a week's working—in which case the manufacturer might be pretty sure that the average would be below the limit. The term, "using the best practicable means," appeared to him to have some advantages, inasmuch as it gave a certain amount of discretionary power to the inspectors; the adoption of this clause was strongly pressed on the Commissioners by Mr. Fletcher. If they found one works reaching a certain standard, they could then fix that standard for other works; and, although it appeared somewhat vague, when read in connection with the suggestion that the Local Government Board should fix a limit from time to time by a provisional order, that appeared to do away with the difficulty, and it would bring many things under the inspector's power, which could not possibly be brought under his notice by any Act which fixed a definite standard. As regards the sulphurous acid given off from coal, Mr. Spiller might remember that it had already been stated that the sulphur acids evolved in the power of manufacture in alkali works did not amount to much more than $\frac{1}{6}$th or $\frac{1}{7}$th of that given off by the coal used in the works. The difficulty of using manganese had already been pointed out; if carried out, it would make sufficient sulphate of manganese to paint the whole universe. It would, no doubt, be a hardship on manufacturers to compel them to do a thing without telling them how to do it; but at the present time it was only proposed that this limit for sulphur acids should be imposed upon works in which they were evolved in the manufacturing process, not upon their production in the ordinary combustion of coal. As to the utilisation of carbonic acid by sending it over hot coke, so as to make it into carbonic oxide, he did not see where the advantage would be, because when it was utilised afterwards in the iron works it would be re-converted into carbonic acid. Mr. Riley's suggestion, that if the absorption of sulphurous acid were to take place at all it must be by means of lime, was more practicable, but as he had pointed out, there were great practical difficulties in the way, the most obvious being the interference with the draught. With regard to automatic testing, Mr. Fletcher had arranged some very neat and accurate apparatus for taking automatically samples of hydrochloric acid. He had an arrangement by which a number of bottles filled with solutions were placed in a box, a fan was worked by means of the draught from the chimney. This set in motion a bellows, which caused the gases of the chimney to be drawn through the absorbing solution, and there was an arrangement by which, after so many revolutions of the fan, the passage of the gases was directed to another bottle. There were about 32 bottles placed in a box, each of which took a sample at a certain time. This of course would not give any indications of escapes taking place from accident, not through the chimney.

The Chairman then proposed a vote of thanks to Mr. Phillips, which was carried unanimously, and the meeting adjourned.

ELEVENTH ORDINARY MEETING.

Wednesday, February 19th, 1879; Lieut.-General Sir Arnold B. Kemball, K.C.S.I., K.C.B., R.A., in the chair.

The following candidates were proposed for election as members of the Society:—

Bray, George, Blackman-lane, Leeds.
Harrison, Robert Henry, Ware, Herts.
Johnson, James Henry, Albert-road, Southport.
Kirkham, Professor T. B., Bombay.
McHardy, Coghlan, 1, Grenville-place, Cromwell-road, S.W.
Pym, Wollaston F., Junior Carlton Club, Pall Mall, S.W.
Somerset, Rear-Admiral Leverson Elliot Henry, 44, Curzon-street, Mayfair, W.

The following candidates were balloted for and duly elected members of the Society:—

Binns, Edmund Knowles, Fig-tree-chambers, Sheffield, and 216, Heavygate-road, Sheffield.
Donovan, H. C., 17, Bonfield-road, Lewisham, S.E.
Harward, Gainsborough, Stourbridge, Worcestershire.
Mathieson, James, India-rubber, Gutta-percha, and Telegraph Works Company, Silvertown, Essex.
Neill, George Dempster, Greenock.
Ross, Thomas, 70, Hampstead-road, N.W.
Smith, Henry, J.P., Summer-hill, Kinswinford, and Brierley-hill Iron Works, Brierley-hill, Staffordshire.
Straube, Albert, 63, South-hill-park, Hampstead, N.W.
Stroh, Augustus, 42a, Hampstead-road, N.W.
Wall, Thomas Leetham, Leyland, near Preston, Lancashire.

The paper read was—

TURKISH RESOURCES.

By J. L. Haddan, M.I.C.E., F.R.G.S.

Officer of the Medjedie, Francis Joseph, &c., late Engineer in Chief in the Ottoman Service.

In the whole history of the world there probably never was presented so unique a chance of starting an empire *de novo*, on the latest principles of political economy, as exists at the present moment in Turkey. Every vestige of order, such as it was, has vanished; there is not even an official nucleus of good to work upon, and the state of affairs is such as would cause, in any other country, the most sanguinary of revolutions.

That this has not been the case, proves beyond a doubt the existence of a powerful controlling power, whose influence, in spite of every suffering which incapacity can cause, is still of value.

This power, therefore, is the only basis left to work upon, for the regeneration of the country and the development of its resources. The Arab proverb says that the fish both moves and rots from the head (the Sultan). His imperial orders, however arbitrary, we may feel assured, will still meet with implicit obedience; but, to attain their object, they must be of such a nature as not to need the visible introduction of foreigners, whose efforts will be clogged by intrigues, and certainly never be accepted with that cordiality which even a chance of success imperatively demands.

Instance the present Grand Vizier, who is literally tied hand and foot by the masterly inactivity of his inferiors, and the more or less open intrigues of his equals.

I must go further, and insist that the requisite Imperial Hatts, or edicts, must be of such a nature as to be carried out without intermediary administrative machinery, since none exists; nay, more, what there is, is of a decidedly negative value.

The only remedies, therefore, which England can, with any chance of success, submit to the Sultan, must in theory be based upon the most scientific model of economics; for there is no margin of either time or money available: but the form, to be self-procreating, must be such as not to present any appreciable novelty in practice.

The necessity for wrapping up, as it were, our good intentions is vital, and is mainly obligatory for two reasons: first, to prevent our offending the susceptibility of the Turk, who holds a position not dissimilar to our own in India during the mutiny. I don't suppose there was an Anglo-Indian who would not sooner have died than have admitted foreign intervention during that crisis; to live ever after playing second fiddle, and branded as incapable in the sight of the subject races over which they had lorded it so long. Secondly, Orientals at best are slow to initiate; and when disaster and ruin are at their doors, any energy left can only be exerted in pursuing mechanically their old avocations. Relieved they must be, of course, from the burdens imposed by bad government; but nothing new, even though plainly evident for their future good, can possibly be received by minds so utterly unhinged. All classes require that repose of spirit by which alone can they work with heart and soul to rebuild their own fortunes and, *pari passu*, that of the State.

If the disparity between our nation and the Ottoman, from every conceivable point of view—geographical, commercial, and ethnological—could be put into figures; it would not be less, I am sure, than 1 to 1,000. We can, therefore, hardly hope that English forms or observances can suit the case, and must expect the remedies proposed to appear at the first blush very outrageous from our point of view; but judged by the abstract science of economics, in which there is no such thing as disparity, for its laws apply equally to the whole universe, my practical suggestions should not appear startling at all. The fact is that, while English forms are so difficult of application to Turkey, sound commercial principles are of far easier introduction than in England; where the fair field, so necessary for a principle to operate in, is cumbered with commercial interests and fallacies so gross as even, as we have lately seen, to deny the merits of free trade. In Turkey we have, fortunately, only administrative and physical difficulties to deal with, the commercial field being virgin soil.

This fact is our great opportunity, and the few edicts the Sultan may have to issue, if prepared upon this basis, will succeed in regenerating the country with far less time and expenditure than by political reforms, perforce entrusted to a body so ruined in constitution as to be incapable of reforming itself, much more others.

It is useless, also, to think of applying legal remedies as a primary reform, when a priest's *fetwa*, or rendering of the Koran, will overrule it. Firstly, law of any kind is avoided as much as possible, and, therefore, its reform will not affect a large class; and then, again, our first principle, that every one is bound to know the law, the prince and the peasant alike, would simply, until all classes were educated up to this point, by a press yet to be created, enable the sharpest to use the law as an additional weapon of offence. This is the case in India at the present

time, where the judge cannot annul an iniquitous or usurious bond entered into by the rayah and the native Shylock, although the former evidently did not appreciate the real meaning of the bond he signed. Government should monopolise the usury trade; it is a very safe investment, and would be a great boon, even if worked upon the Rajah of Cashmere's system, of allowing no one but himself to own and hire agricultural implements, or to interfere between himself and his serfs. To cut away the causes which promote litigation is all that can be done at present in this direction. We must not forget that, *experientia docet*, and how few there are even among ourselves who can really appreciate the lessons contained in printed precepts, unless they are practically brought home to them. The commercial field is, consequently, the only chance available, and to this my suggestions will be found exclusively directed.

Hatt No 1.

The abolition of the innumerable indirect and hand-collected forms of taxation; and the substitution, therefore, of one universal rate, automatically levied upon the movement of money, in the form of a pro-rata receipt stamp.

Mr. Macleod, a leading authority upon economics, says, "It is agreed that exchangeability is the quality which is the essence of wealth, and that every act of exchange is a phenomenon of value;" to which I would add, that taxation levied on the essence of wealth, in lieu of upon the same diluted, is the cheapest method of extracting a revenue; which is, after all, but the quintessence of a country's wealth.

The income tax is acknowledged in England to be the fairest of all taxes, though the expense of its collection is its greatest drawback; by the receipt-stamp system, of a certain per-centage in the pound, levied upon all money transactions, in lieu of on the goods themselves, not only the expense of collection is saved, but all the vexatious and ruinous impediments to freedom of trade now rampant in Turkey are removed. I could not describe to you the diabolical ingenuity with which every Jack-in-office pounces upon the slightest excuse for delaying business. His principles are very scientific. Time is money, so you must pay him, or you will lose time. The physical difficulties of the country to tax collection, one of its most expensive items, are by this plan ignored; but more than all, everybody will be free to plant and sow what he likes, without being subject to every species of extortion, and often in addition to primitive though well meant experiments upon the part of the governors. Not a single chance must be left to these gentry—for their proclivities are in the blood, and cannot be eradicated.

I knew a farmer in the Lebanon, who planted 500 mulberry trees to provide food for silkworms, the staple trade of his district. It is known these trees do not even pay expenses for three years, yet my poor friend, as soon as the last was safely planted, was taxed about £10 yearly for the lot, far more than they were worth. He meditated destroying them, but here again were his hands tied by the forestry regulations. I could amplify examples *ad nauseam*—raw material taxed, and then the product re-taxed, and so on.

Perhaps the most suicidal case I could mention was treating all Turkish grain or produce arriving by sea as foreign, and liable to a heavy import tax; while real foreign stuff, Russian flour, came into Constantinople to the tune of more than a million yearly, at more favoured rates. It is said General Ignatieff managed this; it is more than probable.

The use of stamps is no novelty, since impressed stamps of various amounts are used all over the empire; all petitions and letters to the authorities must be written upon stamped paper: an example our Admiralty and War-office might mercifully follow to choke off inventors.

These stamps would be issued by the banking organisation to be hereafter explained, and consequently the governing class would not touch a sixpence, and be absolutely cut off from all chance of peculation: the stamped receipts for every money payment affording the clearest and simplest of all possible ledgers.

Informers would effectually prevent the stamp duty from being evaded; such a class is unfortunately all ready to hand in the shape of a large class of persons who make a living by pushing their way into all possible concerns for the express purpose of thwarting them, so as to be bought off. Backsheesh does not mean, therefore, paying for petty services, but rather discounting the power to do evil. The ministry of public works used to be particularly fecund in producing this species of parasite, the offspring of want of legitimate occupation.

I estimate the *bonâ-fide* cost of collection of revenue in Turkey at 25 per cent. upon an amount not more, perhaps, than two-thirds the sum actually squeezed out of the population in money and in kind. This would really bring Turkish gross revenue from £20,000,000 up to £37,000,000 annually extracted from the people; and though the times are so bad, the amount of £18,000,000 should be collected without difficulty. To produce this amount I should think a *pro rata* receipt stamp duty of 1 per cent. would suffice. There would be no other form of taxation or dues whatever to give a handle for extortion or an excuse for foreign supervision. My calculation is based upon English figures. The wealth of England is computed at £11,000,000,000 annually, and the taxation at £110,000,000, or 1 per cent. The cost of collection will be almost *nil*, as will be hereafter explained. This plan would give physical freedom of trade, as great a necessity as free-trade itself.

Hatt No. 2.

The absolute separation of the administrative from the financial element.

This effected, the Pachas might work out their intrigues at their leisure, with no worse result to the commerce of the nation than the block of business in our law courts causes us; while the introduction of a distinct financial organisation, independent of administrative changes, would inaugurate that "stability" which is the first great requirement of the country. The extension of the Ottoman Bank branches, and their absorption of the surplus native *employés*, would afford the readiest means of attaining this object, and also of undertaking the other secondary organisations (to be explained further on); for Turkey cannot

afford specialists. The jealousy of the Turk, to which I have referred, does not, fortunately, apply to the lower orders, bankers, engineers, and such like; so they may work actively, without opposition.

The loan of money by the State to the ryots at bad seasons is a necessity in all agricultural countries, and should be a State monopoly, to protect the ryots from usury; so for this one requirement alone banking ramifications are obligatory.

Mr. Von Haas, one of the local directors of the Ottoman Bank, not only showed in Syria how agricultural banking might be safely pursued, but also how the natives were capable of seconding him, when in enjoyment of regular pay and proper control. His knowledge of the interior is as perfect as Mr. Forster's is of head-quarters.

By our Government taking shares in the State Bank, they can assist Turkey far better than by guaranteeing a loan; they would possess more real control: and, by exalting the State Bank to its proper position, would destroy the small fry of financial leeches which bleed the Porte of no mean per-centage of the European loans. It would also stop the game enjoyed hitherto by the Porte, of playing off English against French financiers, who fight for the sake of the pickings of the worthless bone the public are to be persuaded to swallow. *Bonâ-fide* working management can alone improve the situation. It is not to be done by ringing financial changes, however musical; or by Egyptian Commissions, which only prevent wholesale peculation at an increase in the retail.

Hatt No. 3.

That a certain class of debts, whether to the State or individuals, foreigners or natives, are cancelled upon proof of inability to pay.

Internal repudiation is a necessity of the first importance, nor would it fall on weak or honest shoulders, like the failure of the Glasgow Bank. Whitewash would give the Pachas and Effendis a chance of being honest, for there is hardly one who is not held by the throat by some Greek or Armenian Shylock, who is indirectly responsible for most abuses. It would relieve the peasant from the usurer, whose debt is a suspended sword hanging over the poor wretch for generations, and paralysing all his efforts; and would give the Porte, therefore, more chance of obtaining a revenue in the immediate future. At the same time the local courts would have time to contemplate reform during the cessation of their usual occupation of dealing judgments, generally in favour of him who may happen to have the proverbial nine points of the law, if nothing else, upon his side.

Hatt No. 4.

That the "etappen," or post system, at fixed rates, shall be introduced as a semi-official monopoly.

The independent management of mules, pack-horses, and camels, and the want of any system of equilibrating the supply and demand, causes the rates of transport to be abnormally high, averaging 2s. 3d. per ton per mile, the rate, moreover, varying up or down as much as 100 per cent. in a few days; a fluctuation utterly prohibitive of all large undertakings, import or export. These rates can be reduced one-half, and yet leave a profit of 25 per cent.

It is not intended to purchase the animals from their owners, but merely to extend to the whole supply the existing powers of requisitioning transport at a fixed price per diem. Hence no capital need be sunk.

The distribution and working would be conducted on the Prussian military or "Etappen" system, by which the owners would never leave their homes, or the animals have to carry fodder for long journeys, as they have to do at present; each stage or post being only the length of one day's journey. The packs must be removed of necessity each day, so the change of posts causes no inconvenience.

An illustration in example of the necessity of a fixed tariff. A Yorkshireman went to Aleppo some years since, and having the proverbial shrewdness of his race, visited Mesopotamia, and treated direct with the Bedouins for a large cargo of wool. He broke bread and eat salt, and was made a brother in the orthodox fashion, and perhaps, on this account, the wool was sold to him at about half its value. The wool, however, never reached Leeds, in fact, still remains in Mesopotamia, because it turned out the only means of transport belonged also to the Bedouins, who demanded such prohibitive prices that the operation was impossible. The purchase money, it is perhaps needless to state, was not refunded.

The "etappen," or post system, is also the remedy for the state of things in Afghanistan, so graphically described in the *Daily Telegraph* of the 4th inst., as follows. I quote it, to bring you down to the level of Turkish means of locomotion, and to give you some idea of the ruin armies cause in denuding a country of its last straw of transport, without offering any compensation except money, which won't make camels:—

"Bhoosa, it should be explained, is the generic term for fodder, and without it camels cannot go, and without camels an army cannot move. Camels, therefore, form the chief topic of every conversation, just as they furnish the chief feature of every landscape. Healthy young officers dwindle into hypochondriacal skeletons from incessant anxiety and bad camels. Travellers of susceptible character become actually cameline in habits, eating anything, grumbling at everything, and moving listlessly at the rate of two miles an hour. It is impossible to understand, except after actual observation, how thoroughly this quadruped gets into the system and on the brain. If you keep pushing a camel on he dies, if you leave off he sits down. To flattery he pays no attention, and to abuse he has long been hardened. You cannot coax him, and he does not care for blows. But there is a very pathetic side to this animal's existence, and one that makes even the camel-plagued transport officers speak kindly of 'the poor brutes.' Camels require constant feeding—five hours' grazing and five hours to chew the cud is the native's allowance, with five hours for sleep—but in this march from Sukker hither food to their taste is generally scarce, and often altogether wanting. The animal from one province will not eat the herbage in the next, and very few will take grain, so they get little or no food. At every halting place it is the same miserable story. 'Look at these camels; they have had nothing to eat for so many days.' 'Why?' you ask. 'Their drivers will not take them into the jungles to graze, for they say the camels will not eat the stuff there, and, as for buying food for them, the drivers would sooner see their

masters' animals die than part with any share of the money they hope to plunder—money stowed securely for themselves at the cost of fearful suffering to the poor brutes.' This is absolutely the case. Feeling certain that Government will reimburse them for their camels, the owners, when with their beasts, allow them to starve to death; while the drivers, having not even the interest of ownership to consult, take, if possible, less care of them. The wretched camels, therefore, themselves dying of hunger, pace along, laden with food for man and horse, till the end comes. And death is mercilessly slow in its approach. Too weak to advance another step, the great beast lies down at last. His burden is taken off his back, and the string out of his nose. The file is closed up, and the long caravan proceeds, the helpless thing lying quiet where it fell."

It is useless, therefore, to think of extending trade with such inefficient and fluctuating means, until a low fixed rate of transport is secured by organisation. The low rate of freight, like the high salaries proposed by Mr. Forster to the *employés*, raises the price of money all over the country—a great advantage where borrowed capital is employed. Railways do so also, but unfortunately prematurely, *i.e.*, against their constructors.

The average rise in the value of money since the Crimean war has been about threefold, yet in many districts men can still live for 2d. a day, and of course can only pay taxes in like ratio.

The revenue of Turkey, in spite of borrowing at the rate of £10,000,000 annually, has not, however, more than doubled itself. Hence the prosperity of the country has been really retrograde, to the extent of about 30 per cent., since 1874. Anything tending to raise the value of money is therefore to be commended.

The soil presents the only field available for rapid regeneration, for confidence in that has not been shaken; and every man, woman, child, and animal, who can be employed in the work, should be so occupied and assisted to the utmost. It would be the height of stupidity to upset them with reforms,* or to set them to learning new trades, such as making unremunerative roads and railways, or working mines—even if England advanced the money.

It was the opinion of Consul Skéne, of Aleppo, given before the war, that the construction of the Euphrates Valley Railway with local labour, would ruin both the people and the revenue; and I am also of the same opinion. As, however, it is useless to encourage agriculture if we cannot carry the crops to market—although the etappen system will increase the existing capacity of transport about threefold—it will be necessary to introduce some form of mechanical transport, in case of a murrain, for instance; and to set free as many animals as possible for a higher class of work than transport, viz., ploughing. *Pari passu*, with mechanical transport, agricultural labour-saving instruments can be introduced, the repairing shops of the former being available for the latter. It is the absence of mechanical labour which has hitherto prevented their introduction, because it will not pay everywhere to follow the Southern Russian system of never repairing, but buying biennially new machinery. Many persons will advise the stereotyped railway panacea, but unless it can be constructed by imported labour, and be shown to pay with a low tariff, irremediable evil will have been done; "for if a railway on an important line be constructed on so expensive a plan as to require a high rate of charge to enable it to pay a good dividend, the whole powers of an influential body—influential, and powerful, just in proportion to the amount of capital expended—will be brought to bear on that line, not in order to secure cheap transit, but to prevent cheap transit ever being obtained on it."

Unless, therefore, engineers can supply a remunerative or ready money railway, it is worse than useless to think of their further introduction; the present ones having caused that concentration of the population and resources which are so much to be deplored. We are obliged, if we make railways, to start them all over the empire more or less simultaneously. I would again remind you of the discrepancy between England and Turkey, so you must not be surprised if a railway *à la Turque* partakes more of the nature of a donkey and panniers than of a Pullman car; it would be a proof of its unsuitability if it did look English.

The sketch upon the wall gives a view of the pioneer, or steam caravan. It is shown there in timber, to cost £500 per mile, but can be made in Landore Siemens' steel, and erected complete, including rolling stock, at £1,500 per mile. It is a portable structure for prudential reasons, because, until we know more of Turkey's trade centres, nothing permanent is warranted. The rapidity of its installation, and the absence of local demand for labour for construction, are the striking features which (unlike a railway proper) can allow of its extension all over the empire with a trifling capital expenditure; because such a ready money railway can turn over its capital so rapidly, as to be available for almost uninterrupted extensions from the earnings of the open portions: a feat no unremunerative railway can possibly perform. It has been suggested as the forerunner of the Grand Trunk Railway to India, the map of which is upon the wall.

They are, fortunately, not yet trammelled in Turkey, as in Australia, with different gauges, which are due to works being prematurely undertaken, on a permanent and inelastic model. In railways, as in other branches of economics, we have a fallow field to exercise our latest mechanical principles upon—principles which, though acknowledged as ultra-economical, cannot be adopted at home for obvious reasons. I refer to the abolition of weight as tractive power. For the benefit of the uninitiated, I will illustrate the old system as putting a man on a horse to give him extra weight to pull with on a hill, while the Pioneer adopts the continuous brake system reversed, which may be likened to the man being employed to lend a hand to every wheel of the train. The workshops of the whole world are available for its entire production, no local organisation is required, and certainly could not be obtained if it was, organisation being the *bête noir* of the country.

My Turkish principles, derived from daily struggles to make bricks without even straw, have now been shorn of all European pride and pomp, and at last, after strong resistance, brought down to the level of stern necessity. They are condensed into but a few lines, as follows:—

* Even the necessary organisation for affording them relief was too much for many to understand.

In countries where statistics are absent, in order to prevent the natural hesitation in launching forth into public works with that vigour which the age demands, and by which excusable prudence, golden opportunities are often lost, the causes for repentance inseparable from haste must be removed, simply by constructing every such work of a temporary (not trumpery) character, so that the hands of the future are not tied by works indelibly scored into the map of the country, before our knowledge of it warranted even the use of dotted lines. This object can only be effected by making mechanical skill subservient to commercial wants, in lieu of the other way about; and by so reducing the cost and skill required for working, as to enable personal management to take the places of irresponsible administration.

If, however, financiers can still see their way to coach unremunerative railways as a personal speculation, then I would recommend the following form of State guarantee as the only really commercially scientific one:—The State to fix the tariff per ton or per passenger prohibitively low, and make up the difference per ton to the railway company, out of the increased revenue which such a manœuvre would infallibly produce by encouraging traffic.

It is only in exports that Turkey has a chance; and she should abolish import taxes, to enable her people to live cheaper, and spend their all in developing exports.

The chronic state of famine recurring in the various inaccessible parts of the empire, which comprise nearly the whole except the sea-board, show that, just as in India, the Turkish Government must charge itself with the task of maintaining a helpless population when their crops fail. In India this is to be done by increasing the taxation in ordinary years, so as to have a reserve fund upon which to draw in years of famine. This sum it is intended to invest in remunerative works if they can be discovered. Of course this measure does not pretend to either prevention or cure, unless the money be invested in remunerative railways; which, by physically equalising supply and demand, can alone exterminate famine. Money alone cannot do this. In Turkey, I am sorry to say, the State could do nothing at all, but trusted to Allah as the only resource.

Railways are only of limited use unless supported by safe harbours, whose designing requires the most tedious collection of data; the *rationale* derived from which is, moreover, far too often upset by the unforeseen effects due to the obstruction to nature which a solid breakwater of necessity forms. Now, so many ports are wanted all over the empire, that it is evident Turkey cannot afford this mammoth class of structure, but must appeal to Europe to devise something more suitable to her means. Fortunately, nature has given us a hint. The seaweed islands of the Pacific, formed of floating masses of vegetable matter, but a few feet in depth, yield perfect shelter against the most formidable tornados. Mattresses of manilla fibre and cork, or barrel floats, will provide a very simple and efficient substitute. Its position as a breakwater can be shifted and changed *ad libitum*, until practice gives perfection—a rule of thumb method, far more prudent than solid stereotyping from existing models in other countries, where the absence of some apparently trifling factors may upset the comparison *in toto*. Such floating mattresses sown with torpedoes would secure any harbour or fort against attack, quite as effectually as Arctic ice. The cost would be trifling, and the return immediate.

We have a case in point in Cyprus, where a harbour is wanted at once; and the usual six or seven years of observations must be dispensed with. No one even yet knows (how should they?) whether Famagosta or Larnaca will form the best sea capital. Many point to the former, because, at first blush, a spit of reefs, and some ruins, offer the delusive advantage of materially diminishing the cost of a breakwater. But the direction of the reefs is, unfortunately, the worst conceivable, since the mouth of the area it encloses gapes in the direction of the most violent winds, forming a most turbulent *cul de sac*, as the presence of considerable quantities of sea mud proves undeniably. Even if further protected with a mole (as shown in the map), the set of the waves would be across the mouth; so that the chances of fetching the harbour, especially along the lee shore, would be very problematical.*

With a breakwater a mile long, and a mole of about one quarter that length, and after dredging considerably, the area of 5½ fathom water would not be more than 20 acres, or enough for five of our biggest ships, since each requires an area of at least 30,000 square yards to swing in. The cost would be at least £500,000, while the size would not suffice for general purposes, since there is no harbour of refuge along the whole coast from Port Said to Smyrna, a dangerous coast-line of 1,000 miles. Smeaton says, in addition, that tranquility cannot in the present day be obtained in a small harbour, since it must be provided with the unduly big mouth the use of large ships necessitates, the size of the entrance requiring to be proportioned to the area enclosed. A miniature harbour on existing principles is, therefore, as much an impossibility as a miniature railway is. A *cul de sac* harbour is also particularly unfortunate in the Mediterranean, where there is practically no tide to give a back-wash, to clear out the mud constantly driven in by the prevalent or storm winds. On the other hand, the absence of tidal range is highly favourable to floating breakwaters. All these facts must be well known to naval officers who were out in the Egyptian campaign in 1840, when, I am informed, the establishment of a coal depôt was attempted on the island, but recourse had, after all, to be had to Malta. A harbour, therefore, must be made immediately.

In addition to its great political importance, I believe the occupation of Cyprus to be also of the greatest use as a *point d'appui* for commercial attack upon Asia Minor and Syria; and, since our merchants are impatient to begin, and also to develop Africa and other continents in a similar way, I trust they will see the manifest absurdity of establishing military outposts simply furnished with the ultra perfection of means of offence, but singularly deficient in trade weapons, of a nature, first, to assist in the conquest, at a vast saving of

* Nearly half the shipping casualties occur in entering or leaving a port.

blood and treasure; and, secondly, in the holding at a greatly reduced annual expenditure, of the vantage grounds gained for us, either by diplomacy or by the lives of our valiant soldiers and explorers. The bill for dead camels alone would have paid for a field railway in Afghanistan, which Generals Hamlin, Sir Henry Green, and other competent judges, say is the only means of conquering the hill robbers, who, for the most part, are so from poverty and not from inclination. Burning their houses and crops will certainly not improve the situation.

It is not fair to our Generals to handicap them thus. Sir Garnet Wolseley ought to be provided with ready made railways, cut and dried harbours, floating workshops, mills, bakeries, &c., and so on—we shall always find a use for them when he has done with them, in some other part of our empire. Such portable aids to colonisation would certainly constitute the stock in trade of any privately conducted undertaking of a similar nature.

A case in point in South Africa. What a disgrace for a civilised colony to have two of her Majesty's war vessels stranded on her shores, and how fatal such an event might be if occurring at a critical moment. Sir John Coode was not sent for a moment too soon. What can our generals do unless we supply them with suitable weapons? Lord Chelmsford would have liked, perhaps, a cargo of knuckle-dusters for close quarters with the Zulus, while Sir Garnet would like endless things, not perhaps in store, like the unfortunate bell-tents; but still none the less necessary. To sum up, our arms, as it were, are too far in advance of our trade weapons, and Manchester, to keep pace with the times, must supply the deficiency.

The mineral wealth of Turkey is great, but its working must necessarily require time, and most certainly capital; and in addition, the Porte will not give concessions for mines at first hand to Europeans. Fuel is hardly ever obtainable for smelting *in situ*, and to export even these rich ores on mule back is impracticable.

I will conclude my paper with a few general remarks and anecdotes, which will serve to elucidate my points.

The Turk is a most jealous creature; it was jealousy of the superior condition and treatment of the Christians which provoked the massacre of Damascus. The Turk had no friends to protect him from extortion, while the Christians had the consuls and their bishops or despôts, whose influence is paramount over their flocks, no member of which is ever punished without his chief being courteously consulted. In Roumelia there is now a good chance of the Christians returning the compliment.

The regular payment of the European *employés* in gold, while even the highest Turks were mulct of considerable discounts, was another source of jealousy. The provincial accountant is paid, perhaps, a salary of £10 per month, out of which he has to pay all his clerks (a round dozen or so), but he is allowed the benefit of the exchanges, and to act as a banker to the public and also to the *employés*. It is, therefore, his interest to delay payments of all kinds, and he does this duty to perfection. If you want gold he has only copper, if you should want the latter he has only silver, and so on, in the same style as the Spanish Jews of Gibraltar, who never sell anything in the money—judging by your nationality—they think you seem likely to purchase with. Control of such an *employé* is evidently impossible. I have often, too, heard *employés* of all ranks excuse some neglect of duty to a Pacha with the perfectly valid explanation, "he was attending to his own private affairs," by which could he alone eke out a living.

Orders cannot be carried out through a system of administration so loosely controlled; and good pay and a reduction in numbers must, as Mr. Forster, of the Ottoman Bank, suggests, form one of the first efforts of reform; and, could he, by extending his operations, offer better employment to those left out in the cold, he would have the whole governing class upon his side; for many sigh for the settled berths of the Ottoman Bank, and would readily give up fighting and intriguing for Government appointments.

The day's work of a Pacha may be distributed as follows:—To ways and means of keeping his place, 60 per cent. To business forced upon him by Shylock, 40 per cent. The welfare of the country he has time to attend to only in his dreams.

A Turk's idea of economics is very vague. I once heard a Pacha attribute the existence of bad money to the mint coining so many per cent. to cover expenses.

A Turkish Pacha's idea of governing is to tax everything at once, and show an immediate return. His tenure of office being so short, his policy is to slay the goose which lays the golden eggs. How it answers, and how well he does it, we all know.

It is the pride of a Turkish Pacha that he is above the law. We have seen our English Prince gracefully accept, of his own accord, the very contrary. You may appeal in vain to a Turk for settlement of a claim because he owes it to you; but if you appear with a face of abject misery, and ask him to lend you double, you will surely get it if he has the means. This pride of being above law is a serious evil. The four or five head *employés* of a province enjoy and abuse this immunity. Being appointed from Constantinople, there alone can their acts be questioned.

During the period that Achmed Vefyk Effendi was Minister of Justice, a certified complaint against an ex-governor was sent him from a distant province. Vefyk invited the ex-governor to visit him, who, expecting employment, came in grand state to the ministry. In the course of conversation Vefyk obtained from the Pacha himself confirmation of the debt; pipes, coffee, and compliments occupied the usual twenty minutes, and on the Pacha leaving, Vefyk handed him a purse of gold without any explanation. On reaching the courtyard the ex-governor was informed that his sumpter horse had been sold to pay the debt in question, and the balance was the bag of gold aforesaid.

When such primitive measures are necessary—and this only happened a few years ago—it is useless to talk of introducing fresh laws and ordinances, since there is no one to carry them out. The Koran is the law of the land, and a priest's *fetwa*, or written expounding of the same, holds good against every regulation. Where would an European

lawyer be under such circumstances; and until Church and State, the soul of Mahommedanism, be separated, it is useless to attempt the introduction of European judges.

Hobart Pasha has described the abuses of the capitulations and their clogging effect on reform. Provided a few European Courts of Appeal were maintained at the chief centres, the whole system of consular jurisdiction might be done away with. In many places the Turkish courts were nothing like so venal as the consular ones, especially when the consul, not knowing the language, was in the hands of his dragoman. I have known even British consular protection sold to persons who had no shadow of a right to it, and consular judgments purposely spun out to an extent which would rival the old Chancery-courts.

With reference to the Gendarmerie, as far as Turkey in Asia is concerned, it is quite an unnecessary expense. The old plan of setting a thief to catch a thief has answered well in Turkey, for the majority are only fillibusters from necessity. On the Smyrna and Cassaba Railway, the Zebeks formed the most reliable of watchmen, and their utilisation reflects great credit on that company.

The old Turkish plan of making the district or village responsible for all crimes, by fining them, always managed to bring the prisoner to justice, without the head authorities having the trouble to run after him; since, like village gossip, everyone's deeds and movements are known. If there was the least doubt as to which canton was responsible, the lot would be fined with the strictest impartiality. The system of representative government, too, has completely broken down; for the various councils, which are all packed, are merely employed to shift the responsibility upon the local boards. Centralisation has the same pillar-to-post effect, for reference to Constantinople for instructions is the excuse the governor always puts off inconvenient local pressure with. The old system of an autocratic governor assisted by a chief cavass as executive officer, worked far better. For, did he right or wrong, there was no shifting the responsibility; and there was a great deal of primitive justice dealt in cases now out of his reach, by reason of endless rules and regulations, which only serve to clog a good man and shelter a bad one.

Neither reforms nor trade can be forced upon Turkey from without; all Europe can do is to remove every possible physical or financial obstacle to freedom of trade, and to render administrative changes as harmless as possible, by severing their connection with finance; for it will take several generations before the harem influence can be abolished. All we can do is to make it harmless, by putting its influence in quarantine as far as money is concerned, and, in addition, diminish the number of harem candidates for Government place by offering alternatives more permanent and inviting.

The late Sultan's mother once slippered the great Ali Pacha because he refused a pachalik for one of her *protegés*. He was standing abjectly one side of a curtain and she the other, in the usual orthodox style, when his ears were suddenly made acquainted with the lady's yellow slipper. He had to give in.

The late Sultan was also tricked by one of his grand viziers in the following manner:—Imagine the imperial rage when he discovered that he had been hoodwinked by his vizier, whom he is accustomed to treat like a dog, who never sits in his presence, and claims to be dirt, and so on. The Sultan had noticed that the interest of each successive loan was higher than the preceding one, improving, as he thought, and wished to exchange nearly 7,000,000 of Turkish consols for a like amount of the new loan, simply to enjoy the additional interest. The exchange was made, but, unfortunately, the new loan miscarried. The vizier paid the interest, as it fell due, while he was in office, and thus staved off the day of reckoning. I suppose the death of Abdul Aziz settled the question, for it happened only a few months previously.

The late Sultan's attendants were often of the lowest rank, for he was so fond of animals that any one bringing him a rarity was sure of a place of honour. I once saw in the royal menagerie a Cyprian goat decorated with the Osmanie. While inspecting the animal, it chanced to thunder, and the chamberlain most seriously said, "Ah! Mahomet is having a fine game of skittles with Allah." He said it in perfectly good faith.

Before, however, you can half realise what Turks really are, I am afraid you must camelise, as the *Daily Telegraph* has it. The raw material is without exception the finest in the world, sober, straightforward, industrious, and easily contented. And the errors of the governing class are really more the fault of circumstances than their own. The substrata being so good, we need not therefore despair of regenerating the country, provided the good elements have a fair field and no favour. In conclusion, I may state that these observations more particularly apply to Asia Minor and Syria, where there is any amount of latent wealth, mineral and agricultural; there is no lack of produce of which the rest of the world stands in need; but the inhabitants are poor and listless; there is no uniformity of taxation, no security for property, no encouragement to capital, no communication with the coast, save by occasional caravans, no protection against the incursions of barbarous and predatory tribes, no enterprise, no initiative, and practically no Government worthy of the name. Such is the picture in the present day drawn by the *Times* correspondent, of a land which, almost from the dawn of history, has been the seat of great empires and flourishing civilisations; which has supplied war indemnities not inferior to that paid by France to Germany.

I am indebted to Sir John Lubbock, Mr. Lewis Farley, and also to the gallant Chairman for presiding, but they are not in any way to be deemed responsible for the views I have enunciated, which are derived from personal experiences almost unique.

DISCUSSION.

Mr. Ayton said that, having been connected for some years with one of the leading locomotive firms (Stephenson's, of Newcastle), he should not like the meeting to think that they could not make an engine which could do as much as Mr. Haddan said his could. The fact was, they had never been called upon to study such rigid economy as was deemed necessary for Turkey. The English system of locomotive traction had its economical maximum on a gradient of 1 in 300, and it had been attained on some

of the earlier English lines by a great expenditure in cuttings and embankments; but by Mr. Haddan's system the limit was about 1 in 9, to 1 in 7, which was a great advantage, because in the roughest country he could adopt any gradient necessary without resorting to expensive earthworks, which in tropical countries had the further great disadvantage of interfering with the watercourses.

Mr. B. F. Cobb said he came in the hope of hearing something about Turkish resources, but he must confess he was not much the wiser on that point. He did not know what Mr. Haddan meant by saying that the difference between England and Turkey was not less than 1 in 1,000, and should like it to be explained. He also said that all kinds of law should be avoided as much as possible, and that a large class in Turkey paid no attention to law. He recommended that the Government should monopolise the usury business which would be a safe investment and a great boon—that was a novelty to him in political economy. He also said that he should abolish all kinds of taxes, and substitute a universal rate by means of a receipt stamp, and in support of that, he said that the income tax was acknowledged in England to be the fairest of all taxes. Now he found that the members of the House of Commons spoke of it in the most opposite terms, not only on account of the cost of collection, but because it was one of the most unfair taxes ever levied upon the people of this country. Mr. Haddan estimated the *boná-fide* cost of collecting the revenue in Turkey at 25 per cent. on the nominal amount, but did not state what the amount was. Then he recommended the extension of the Ottoman Bank branch, and their absorption of the surplus native *employés*, and that the English Government should take shares in this State Bank; but if he expected the House of Commons to do any such thing he thought he would have to wait a very long time. Next, he recommended a universal repudiation all round; whitewashing the Pachas, for the purpose, he said, of giving them a chance of being honest. He thought it would be a small chance, after that general whitewashing. These suggestions all seemed to culminate in the Pioneer Railway, which he had heard about before, and did not come to hear about it that evening again. Mr. Haddan proposed, not to purchase the animals, but to requisition them at a fixed rate per day, which was the most arbitrary, despotic system ever introduced. It was frequently done in time of war, but always with the most deplorable result. With regard to the Yorkshire man who went to Aleppo, he did not think he had the proverbial shrewdness of his race, or he would not have bought wool up country without seeing how to get it down. Having made these suggestions, Mr. Haddan stated that it would be the height of absurdity to upset the Turks with reforms, and set them about learning new trades; but he could not reconcile that with his other statements of the improvements which should be made. Again, he understood that the railway was to be the property of the Government, or, if it belonged to a company, then the Government were to fix a tariff—prohibitively low, to make up the difference out of the increased revenue. He should like to ask where the increased revenue was to come from? He had only one other remark to make, about the extraordinary breakwaters suggested, made of manilla fibre, &c., which were to protect fleets of ships, and to be moved *ad lib.* Certainly, for thousands of years, people had been making moles in the Mediterranean, and if this mode were practicable, it would certainly have been adopted. He doubted very much whether it was possible to make such things to hold together so as to protect ships which were anchored inside. If they were left to move with the force of the winds and waves, no doubt they would hold together, and a ship driving to leeward would be protected, but when it was fixed, and had to withstand the wind and waves, it would soon go to pieces. Mr. Haddan said something about the harbour of Cyprus, but a short time ago Mr. Hepworth Dixon, who had just returned from there, gave a very different account of it in that room, and the view now brought forward was diametrically opposed to that given by Mr. Smith, the First Lord of the Admiralty, and other competent men who were out there with him. He hoped Mr. Haddan would be able to give some explanation of these points, and he would also draw his attention to the description he gave, in the last few paragraphs, of Turkish Pachas and their ideas of government, especially with their pride of being above the law. Yet these were the gentlemen, who, it was suggested, should form a national bank to be shared in by the English Government.

Admiral Selwyn said he had been in Constantinople during the year of the war, and in close connection with all the governing body, from the Grand Vizier and the Sultan downwards, and he must say that he had formed a very opposite opinion of the governing powers, and general intelligence, and honesty of those much-abused governors to that which was generally entertained. He had admired Mr. Haddan's success as an advocate of the Pioneer Railway, which was just what was wanted for the mountains in the western parts of America, where something similar had been tried; but as a political economist he did not think, to use an American phrase, that he was quite so great a "successist." He recognised the value of what had been stated, that the population of Turkey—not a small population as was supposed, but nearly equal to that of the large kingdoms of Europe—was above all an industrious, and sober, and an obedient population. Where the peasant was of such a character, princes and peers would be easily changed and modified to suit circumstances. But if people would only consider what would happen in any of the great kingdoms of Europe, if they were attacked by ambassadors coming from every other country, and telling them to-day to do this and to-morrow that; and if, added to that, they had a preponderating element of the worst kind in the world—that of the Armenians and Greeks—the two elements pre-eminent for their greed and dishonesty, he doubted whether any European nation would have stood up so well under such an ordeal as Turkey had. It had been said that great expense had been engaged in without sufficient reasons, that money had been squandered amongst Pachas, and devoted to things not worthy of expenditure. But what were the facts? They found the Turkish nation, threatened for centuries by a great enemy—preparing quietly and cautiously the first element of success under such an attack—a powerful fleet; secondly, the best artillery known in the world; thirdly, the best infantry arm that could be found; and had attention been able to be paid to the cavalry, which was the last and most expensive branch, he was quite sure they would have had a totally different tale to tell. He was living in Constantinople, not in an hotel, but in a large Turkish college, where he had around him a thousand men and boys, diligently seeking instruction, and as orderly as any students in any college in the world, sober, attentive to their masters, closely supervised—principally by Europeans, though the head was a Turk. He also had the pleasure of being acquainted with Vefyk Pacha, and a more intelligent or more highly instructed man was not to be found in the world, or a man more fit to govern an empire, were it not for certain little peculiarities which prevented him from being successful in the post he occupied, because he excited undue jealousies. In Turkey there was, unfortunately, the uncertainty of power, and you never could have, in any country, a successful Government unless it was founded on some basis of security. If it could be turned out by constantly recurring intrigues, it was impossible for it to be other than corrupt. The same thing obtained in great republics, from the same cause; and many of his friends in the United States of America lamented that

they had not a more stable Government. Turkey was a fine country, with a magnificent population, willing to obey European officers (as the rear guard sufficiently showed when Baker Pacha and 13,000 Turks defeated 40,000 Russians), anxious to have Europeans, and especially Englishmen, amongst them. But they must be there in large numbers, not one or two in a whirl of the lowest class of intriguers, the Armenians and Greeks, who were always to be found at the bottom of every intrigue. With regard to the means of opening up the country, he thought that Mr. Haddan had undervalued the existing harbours. Two of the finest steam harbours in the world existed in the island of Mitylene, close to Besika Bay. It was true that Cyprus was not, perhaps, most favourably placed for the purpose for which we had taken it, but he should like to warn Englishmen of one point, which would make some harbour, either at Cyprus or Mitylene, absolutely necessary. The traffic of the world was going to change, in consequence of steam. The cutting through of the Suez Canal had made the most direct route for Eastern traffic from Suez to Salonica. The Austrians had seen that we were now pushing down to get hold of the lower part of the country, and would soon have a railway finished to the port. The harbour of Mitylene had the great advantage of giving shelter at the precise point at which we had always required to watch the Dardanelles. It commanded the harbour of Dedeagatch, which was the terminus of the railway coming from Adrianople, and any advance from the north of Constantinople must necessarily be made by that line, so that any force landed there could flank or cut off any invading army. He disliked the idea of making new harbours, by whatever process, where there were existing ones for the purpose, though he must say that the plan suggested had been tried at Brighton, and answered perfectly, except that the cable which held it got damaged, and at the first gale of wind it went on shore. One could not ignore such a centre of traffic as Constantinople, with communications to the whole Southern Empire of Turkey, and there was no good reason why ships could not continue to use the magnificent port, and the produce be taken from there to wherever it might find a market. It was quite possible, with the aid of such cheap railways, to open up the whole country without any great strain upon anybody's resources; and if that communication were made, commerce and prosperity would result, but it was no use going to work on the old lines, with each ambassador pressing his own views and ignoring the welfare of the whole country whose interest he professed to consider.

Mr. G. Hagopian said he was an Armenian native of Turkey, and he desired to meet the strictures passed by the last speaker on the Greeks and Armenians; but first he would make a few remarks on the paper itself. It was valuable in several points of view, because it put forward certain novel ideas, but it must be borne in mind that the Turks were the heirs of the traditions of the ancient inhabitants of the country; whatever civilisation Turkey could boast of was handed down to her from the Persians; the music, the poetry, modes of salutation, the politeness, were all derived from the Persians. From the remotest times the system of backsheesh reigned supreme in Persia, and it was owing to these traditions that it was tolerated, and would probably be so for a long time to come, until a higher stage of civilisation was reached. Some of Mr. Haddan's ideas as to the establishment of railways to carry goods and prevent famines were very good, and his form of railway was certainly most suited to the country. As to economic and administrative reforms, the Turks had a good deal to learn from the English and French, but the question was were they willing to learn? He must say they were not; they would have to be made to learn. One Pacha consulted one set of interests, and another another; one was pitted against the other; and while the Pachas were playing this game the people were dying of hunger—not only physical, but moral. What Turkey required was administrative reform in the first instance—security of property and life. What was the use of regiments, harbours, and edicts, if you had not the first elements of good Government. Public opinion in Turkey was in its infancy, and everything had to be done by the command of the Sultan; everything must come from above, nothing from below. With regard to the Armenians, towards the end of the last century they introduced printing into Turkey, and for more than a hundred years the Mint was under Armenian administration, because it required great honesty and great ability. The Armenians were the best architects in Turkey; the palaces, mosques, and all the best houses were built by them. As for their standing in Turkey, if one gentleman's opinion was to be set against another, he would take Mr. White, an American Missionary, who resided in Constantinople for many years, who said they were the Anglo-Saxons of Turkey. As for the Greeks, they supplied the necessary intermediary link between the Turks and Armenians. If the country required a little leaven of cleverness and eloquence, you found it in the Greeks, while the Armenians supplied stability. In fact, without these two races, it would be impossible to improve Turkey. If you wanted honesty, you must first obtain security for life and property.

Mr. Scott Russell, F.R.S., said he both agreed and disagreed with so much of the paper, that he did not know where to begin. He quite agreed that the organisation of Government in Turkey was simply an utter disorganisation. The people were, to his mind, amongst the most diligent, frugal, hardworking, honest people amongst whom he had ever lived, and he was going to say that they were very good Christians, and that many Christians would make very bad Turks. It seemed to him that Mr. Haddan took his standpoint of what he would do, as if he were himself the Grand Turk in Constantinople, laying down a mode of government for the people. That was a very good standpoint to take, and his reforms were of a somewhat drastic character; he would cut off everybody from everything they were now doing, and put them to doing something else, which they would be quite incapable of doing. His recommendation for the finances reminded him of one given some years ago by a great politician—he would not say it was not Ignatieff—who had it in his power to recommend the late Sultan what to do in order to benefit himself and improve the country, and, above all, to be independent of England. He said, "Become bankrupt;" and he became bankrupt, and what followed they all knew. He feared that Mr. Haddan had, in this point, followed a bad example, and, having already done it once, he did not think the Turks would gain much by it the second time. He agreed that Turkey and Asia Minor was a grand country, that its agriculture was the main source of its future wealth, and that the development of its great resources was the great work in which any true friend of Turkey should assist. Some years ago he was officially invited to visit Turkey, examine some of the public works of the country, and advise the Sultan what was best for him to do; and he gave him just the contrary advice to that of the personage he had before alluded to. He told him, that as far as he could find out, he had allowed his finances, his railways, and public works to get into bad hands, and he advised him to get out of the bad, swindling hands into which he had fallen, and put his railways and public works into the hands of honest men, whom he could point out to him. Then he said, do not go to the second, third, or fourth rate bankers; go honestly and straightforwardly and get your money from the three or four best bankers in Europe, at a moderate price; give them all the security you have got, and you have plenty of security. I undertake that, if you allow the administration of your finances and

public works to be conducted by them for your benefit until they pay, they will pay; and then to be handed over to you. The great man said—But that would be handing the country over to England! So it would; and what a blessing it would have been to Turkey if this had been done. With regard to the future improvement of Turkey, he agreed that a provisional railway would be of the greatest use in an undeveloped country, and that you ought not to begin by making extravagant works, but wait until such as you could conveniently use were found to pay, and then convert them into more permanent works. The Americans had shown us how to do that. They made a railway that certainly cost less than £3,000 a mile, taking the natural line of the country, not making costly earthworks, and as soon as they had created more traffic than this cheap line would carry, they substituted for it a good pattern railway. But this temporary railway was a very bad idea for developing the great lines of Turkey. There were lines already nearly completed from Charing-cross to Constantinople. He had gone a great part of the way by rail, and there was not much wanting except that which would now be completed, since the international arrangement between the three Emperors and England had probably been completed. There was no difficulty in crossing the Bosphorus at Constantinople by train, and having done that, there was an easy line of country to Angora, and from there there was a fine tract going into the neighbourhood of Mount Ararat; he did not recommend the line going to the top of the mountain, but to one of the rivers which ran from these to Mosul, from whence there was a convenient way to Ispahan, from thence to Shiraz, and so on to Hyderabad, and all India. That must be done on an international gauge, not broken up by exceptional lines, though pioneer lines would do very well for developing local traffic. The Suez Canal had established one absolute line of communication for our commerce with the East, and the whole of it would in future go by that route to India, and therefore he from the very beginning was of opinion that the Suez Canal should have been the property of the British people. That, unfortunately was not done, but at the present moment two-thirds of the cost of the canal was being paid for by English traffic, though the canal was not ours. A watching station within easy reach of the Suez Canal was a very wise thing for England to possess. He would not say Cyprus was the best place, for he was not a judge, nor that Famagosta was the best possible harbour, for he had not seen it, but from what he had heard from those who had, he had the impression that it was not a good harbour, but could be made so by the expenditure of £150,000. If that were so, the island of Cyprus was a very cheap station indeed; at any rate, it was very convenient. He agreed that Constantinople was the grandest station in the world, and therefore he wanted the Charing-cross and Calcutta railway to pass through it. That would make us masters of two lines to India and the East. In the case of a European war we could rely entirely on the sea line, and in case that were interrupted, we should still have the international communication, to be used in harmony with the other Governments of Europe.

Mr. A. Rogers could hardly believe that Mr. Haddan proposed to substitute a system of stamped receipts for every other form of revenue, such as land revenue, customs, and the like. Had he really considered how it could practically be carried out? It seemed to him utterly impracticable. In the Turkish empire there must be thousands of villages with large populations, and how could such a system be carried out; would he have an army of inspectors, to see that everybody in all the little daily transactions of life gave a stamped receipt? Then, again, the idea of a State bank which should monopolise all the banking and usury of the country seemed open to the same objections. How could you establish sufficient agencies to meet the requirements of all the little cultivators. In India the ryot went to the usurer, not only for £50 or £100, but for money for all his petty expenses, to purchase seed, and even clothing for himself, and he presumed it was much the same in Turkey. With regard to the third proposal, that all debts of a certain class should be wiped off, if it included Government debts, he thought it would be quite sufficient to negative the idea of a State bank.

The Chairman said it was quite right in Mr. Haddan to state that, in taking the chair that evening, he must not be supposed to endorse the views put forward, for he must say that many of them were not in unison with his own. They knew that a country which comprised some of the richest and most flourishing countries of the ancient world, but which had lain fallow for centuries, must still retain the means of material development which contributed to its former greatness; and consequently there could be no greater field for capital and enterprise than the Asiatic provinces of Turkey; but the mode in which the enterprise was to be applied was a moot point that could not be determined by mere generalities, which took no account of the inveterate habits and religious prejudices of the people. This question was influenced by so many conditions, to which Mr. Haddan had himself referred, that he hesitated to accept the panacea suggested, of mere paper resolutions, or to believe that a state of things which had baffled the efforts of some of our most eminent statesmen could be susceptible of such simple remedies. The fiats of a Sultan, contained in innumerable hatts, could not be more efficacious than they had been hitherto in overcoming that opposition and intrigue to which reference had been made, and would be even less efficacious now than before in inspiring confidence in the natives and stimulating their dormant energies, or in inducing foreign capitalists to supply the means by which this development was to take place. On the other hand, he believed that the future regeneration of Turkey would depend in a very large degree on the progress of material development; but the very initiation of this must depend on the sense of security which the Porte, with the aid of allies, would be able to establish, under conditions which should afford some guarantee for their permanence. The only chance lay in a community of interests, but that must be accomplished by a community of obligations and responsibilities on the part of the governing bodies, and they must be guaranteed by such special contracts or conventions as should render the action of these bodies amenable to the public opinion of Europe, and make the rights and privileges of all concerned subject to some kind of control. Without this, he did not believe the thing could be done. Mr. Haddan expressed an opinion that the mere construction of railways in Turkey would ruin the country and the revenue, but Mr. Scott Russell had expressed an opinion to the contrary, and he, as vice-chairman of an association formed for the purpose of promoting this main line of railway, could hardly be supposed to endorse such a view. His firm conviction was that the establishment of a railway of that kind would be the best means of promoting reform, by introducing some sort of responsibility in the native government, and that, in fact, by the community of interests which it would establish, it would give us the opportunity of extending something like order, organisation, and justice. Mr. Haddan proposed that his new system should precede it; and, in the sense mentioned by Mr. Scott Russell, no doubt that would be an advantage. He had always understood that this railway was an invention of Mr. Haddan's—a novelty which required the test of experiment, but it seemed now that it had actually been worked; and he could say he wished it God-speed, for if a line could be made for £500 a-mile,

it must unquestionably improve a country, and aid in its agricultural and mineral development.

Mr. Haddan, in reply to the various speakers, said he had no wish to reflect on mechanical engineers, in taunting them, as it were, with making steam elephants instead of steam mules; as Mr. Ayton had said, if they were called upon to make the latter, he had no doubt they could do so. Mr. Cobb could not understand his comparison of 1,000 to 1, which only showed that he had not come down to "camelising point," and could not, therefore, view the subject from a Turkish point of view. Usury was the curse of India, as he was informed on high authority, and he had seen something of it himself; he did not say that the Government should be usurers in the 90 per cent. sense, but at 5 per cent., and no one could deny that that would be a great boon to the country. What would Mr. Cobb do if he had servants in his own house whom he could not trust with anything? It was all very well to talk of an administration for taxing people, but the collectors of the revenue put the greater part in their pockets, hence he proposed a means by which no one would touch the money at all. He did not say it would be possible to collect the whole revenue of the receipt stamps, and no doubt a good deal would be lost, but nothing like so much as the present. Of course the rules he laid down were not to be carried to an absurdity; he did not go into details on questions outside his own profession, but merely suggested the principles. No one supposed you could organise a country in a week, although, perhaps, the *modus operandi* could be settled in that time. An income tax was the fairest tax; he did not say the mode of raising it in England was the fairest. Which would be the best investment for a man who wished to do the country good—to take shares in a European bank you could trust, or to lend money to the Turks whom you could not? As to the whitewashing, what was the good of holding a debt over a man's head, when you knew he never could pay it; but if you set him free you gave him pluck to try again. In India, a man borrowed £5 to-day, and was not free 20 years hence, though he had paid perhaps £5 a-year all the time, besides giving his own labour and that of his family into the bargain. That was what usury meant in Turkey. It was no use saying it did not suit English ideas of finance. Turkey was very different to England. If Mr. Cobb had seen as much of requisitioning as he had, he would not perhaps retain his opinion of its unsuitability to the object he had in view. The evil of the system was, that it always came at the moment when it was not expected. If you had made a contract to transport a certain quantity of grain on a certain day, and all your mules were requisitioned, it was certainly very hard, but if you were told beforehand that they would be requisitioned at a certain price the whole year round, it was not a hardship, but a blessing which any owner would jump at. The advantage would be that, whereas now you often saw one string of camels going to a port for a load, and meeting another string coming back, and waste of this kind in every direction, organisation would be introduced. With regard to the railway guarantee, the usual form was assurance of so much per cent. dividend, which was simply a premium for extravagance; but if, on the contrary, the company said it required 1d. a ton to make the line pay, and the Government said—You must not charge more than ½d., and we will make up the difference, that would develop the traffic, for which they pay their ½d., and indirectly the Government would reap the benefit. In England, railways improved building land immensely, without benefit to the company, but in Turkey you cannot afford to throw away money like that. With regard to the breakwater, he would refer to what Admiral Selwyn had said as to the efficiency of floating breakwaters. Mr. Cobb was evidently not aware that waves did not travel, although they appeared to do so; they exerted their efforts vertically and *in situ*. He had heard Mr. Hepworth Dixon at the United Service Institution, and the fact was he was a word-painter, and not an authority on harbours. It was all very well to hear him describe the glories of Olympus and all that sort of thing, but he had lived at Cyprus, and when the sun was 150 degrees on your head, you did not care to look up to Olympus and get it in your eyes. He did not propose a Turkish National Bank, but the extension of the only organisation there was in the country. If you wished to do a prudent thing in business, it was much better to go into a going concern than to start a new one, and the only going concern in Turkey was the Ottoman Bank. With regard to Admiral Selwyn's remarks, he happened to know that he did not fall amongst thieves in Turkey. He lived in Constantinople, which was not at all to be compared to other parts of the country. No doubt, the army and navy were first-rate, and if you wanted anything done you must go to the soldiers or sailors. With reference to the harbours, he had merely referred to the Syrian coast. Mr. Hagopian was a friend of his, and he was indebted to him for learning Turkish, but he did not think he would deny that the Greek and Armenian bankers were amongst the sharpest class ever made. With regard to Mr. Scott Russell, he would say that he clearly stated that his object was that no apparent change should take place in the empire at all, and that nothing should appear new. That was why he recommended the stamp tax, but it might be combined with minor local taxes, such as a tax on salt or tobacco, or even a poll tax, so as to reach the poorest class. The great thing was to avoid the visits of the tax gatherer, because you could not trust a man to walk from one end of the room to the other without something disappearing. He would ask whether arbitrary edicts were not better than revolutions? Everything was arbitrary in Turkey already. The Pioneer Railway was not intended to compete with ordinary lines; but Mr. Brassey refused to undertake any contract in a place like Turkey unless he had some mechanical means of economising labour, and therefore he believed that something of this sort, used as a contractor's plant to run 50 miles a-head and aid the construction, would save 30 per cent. in the cost of the line. As the main line was finished it would be taken up and turned into branches to serve the main line, by which alone could it earn a dividend. Mr. Rogers's remarks were pertinent, but he would ask him not to think everything was impracticable which seemed so to English ideas. Things were very different in Turkey, everything there was arbitrary. The bank was already established, and he only wanted to extend its operations. It was quite true it could not go to every village and provide for second and third purchases, but because it could not go to the finger tips it was no reason why it should not go to the elbow, or to the wrist, or the knuckles, at any rate, some distance. The gallant Chairman had slightly misunderstood him; he did not say that the construction of a railway would ruin the country, but its construction by local means. If it paid 5 per cent. in three or four years, which was as much as any Indian railway had done, that was not a profitable investment of labour, which employed in agriculture would produce 200 or 300 per cent. yearly. At the present time the population in the country the line was to traverse was only 30 to the square mile, or 7 able-bodied adults, available for agriculture, and it required 28 to conduct agricultural operations properly. Where, then, was the balance to come from to make railways? Therefore, he said, you must introduce some mechanical means to save labour in construction. In a book published that day by General Cunningham, on South Africa, it was stated that to get men to make railways, the contractors were obliged to bribe them with what might turn out to be the lives of 400,000 people. These wretched Zulus would not work on a railway unless they were paid in

guns, and they had had 400,000 guns given them for constructing earthworks. Sir Theophilus Shepstone said, when we took over the Transvaal, there were only 40,000 European settlers in it—a country as large as France—and he could not spare one as a frontier guard; it would be better to pay men £100 a year apiece for the purpose, than take one of the settlers away from his plough. In Turkey there was also the question of forced labour, which was advocated by Sir Macdonald Stephenson for railway work; but he had worked with it for three years, he had to work night and day, and his salary and the salary of the other engineers, with the cost of tools, &c., came to more than they could have got the work done for by contract. Admiral Selwyn had referred to pioneer lines in America as working, which statement had led the Chairman to question the novelty of the invention. He had always stated in public that "one-legged" or single line elevated railways were half a century old. But it has not hitherto been possible to introduce the system, except for horses, although its merits are undeniable, because no cheap viaduct could be made to carry the necessarily ponderous locomotives of the present day. He had solved the question by providing a steam generator, in which concentrated weight is not required for obtaining tractive power. This was his invention; not the whole.

The Chairman then proposed a vote of thanks to Mr. Haddan, which was carried unanimously, and the meeting adjourned.

CORRESPONDENCE.

GAS ILLUMINATION.

As I could not attend the meeting at which Dr. Wallace read his paper on "Gas Illumination," will you kindly permit me to make a few remarks, which your published report of the discussion that took place afterwards, makes necessary. The discussion might have been more generally profitable had the purely personal element, as to whom belonged the credit of certain modifications of gas burners, been left to be settled in some other place. However, as the subject was gone into, and as credit was claimed where it was not due, it is but fair that the honour should be properly placed.

Mr. Sugg claimed to be the inventor, about seven years ago, of what he called the hollow-headed burner, to which I have given the title of slit-union, because it gives the same shape of flame as the union jet. Now, this burner was first patented in 1860, by Joseph and James Wadsworth, of Marple and Salford, who sold the patent to Ralph Heaton and Sons, of Birmingham, and the burners have been manufactured by them ever since, and millions have been sold; and I now forward you specimens. About 1872 it was copied into steatite by the German steatite burner makers (we have no steatite burners made in England), and last year I took out patents here, and in several foreign countries, for manufacturing the same burner from my own material, "enamel." It would, therefore, be interesting to know where Mr. Sugg comes in, as either the inventor or manufacturer of the burner in question.

Mr. Sugg also stated that he believed "the Sugg-Letheby burner was the first in the direction of consuming gas at a low pressure." He will therefore be surprised to learn that there were scores of thousands of burners sold, in 1858-9 and 1860, in the north, and, I believe, in London also, having a large burner at the top, some with an enlarged conical, and others with a barrel-shaped middle, and with a small burner or hole at the bottom for diminishing the flow of gas. There were many burners patented about this time, one of them being by Mr. Hart, which obtained a good sale. The Wadsworth's, above mentioned, also included in their patent an arrangement for lessening the pressure. From this time, to the advent of the Sugg-Letheby burner, many others having a similar object in view, made their appearance, and more were recorded in the Patent-office. And almost any gas engineer of 20 years' standing will be perfectly familiar with the facts of the existence of this kind of burner, and it was by an experiment with one of these that the writer's attention was first directed to the subject of improved gas lighting. Perhaps the discrepancy between Mr. Sugg's statement and my experience may be capable of explanation, and I think, requires it. Geo. Bray.

A NEW APPLICATION OF RAPID OXIDATION, BY WHICH SULPHIDES ARE UTILISED FOR FUEL.

I claim indulgence for a few remarks on the various points so ably discussed by the several gentlemen who addressed the meeting on the occasion of the reading of my paper at the Society of Arts on the 12th inst. My intention was to reply the same evening, but the usual limit as to time having been considerably exceeded, I was unable to do so. It has afforded me great satisfaction to find that so many scientific men have so generally approved the soundness of the chemical principles involved in my process, and also that in their opinion there appear to be no insurmountable difficulties in its practical application.

I will now pass on to those topics on which it appears to me necessary to say a few words; and, following the order of my summary, I would, in the first place, notice the question put by Mr. Lomas, as to whether actual condensation of an atom of sulphur took place. As I explained, the experiments were unavoidably made in apparatus very inadequate and unsuitable. It must be manifest that it was impossible to connect with a Bessemer converter the appliances necessary for the condensation of the sulphur. Of the two atoms of sulphur contained in pyrites, although I have calculated on obtaining only one atom in the free state, I have reason to believe that part of the second atom will also be so obtained. There is abundant evidence that large quantities of sulphur vapour passed off during the whole operation, and we must wait for the experience of the future to decide absolutely the relative proportions of sulphur and sulphurous acid. In the meantime, as it is admitted that the whole of the air driven into the protosulphide was deoxidised, it is only reasonable to conclude that at least one of the atoms of sulphur will be expelled in the free state.

With reference to the opinion expressed by Mr. A. H. Allen, of Sheffield (when speaking on division "H"), that the temperature required would be probably 1200° Centigrade, doubtless Mr. Allen is more correct; it is, however, satisfactory to find that he considers that with this higher temperature there is still ample margin for the addition of sufficient silica to form a suitable slag even when employing a cold blast.

The next question to be considered is that of the selection of a material for lining best calculated to withstand the action of the oxide of iron. I believe that we shall have sufficient heat to enable us to add and fuse an excess of siliceous flux. If so, we should produce an acid slag which, in my opinion, would not materially attack the gannister lining. I further think that, at the temperature requisite for the operation, an orthosilicate slag would be formed, even with an excess of silicate present. I have been favoured with the following letter from a well known authority on such subjects:—

"Sheffield, 13th Feb., 1879.

"Dear Sir,—I am much obliged to you for the copy of your paper, which I have read with interest. I am of opinion that if sufficient heat is generated in the

process to admit of sand being added in sufficiently large quantities to produce an acid slag, that the action of the oxide of iron on the lining will be reduced very considerably, but I fear that you will find that, whatever you do with a gannister lining, the action will always be very great, and the linings, if made of ordinary thickness, will require either repairing or renewing very often; but there seems to me no reason why the linings for your process should not be made an extra thickness. They might be made two or three feet thick at very little more cost, particularly if your plant is erected in the neighbourhood of a gannister seam, and if you decide on using fixed converters, a spare one or two would be no very great object, and when one was worn thin the bad place could be easily repaired or patched with the same material mixed with a little fire clay, after which the lining would be as good as ever or nearly so. It is possible the basic lining may help you (when it is perfected), but this I fear will have its little drawbacks, as I have already explained the gannister lining, when thin, can be easily repaired, but it is doubtful whether we should be able to do this with the lime lining, and if the whole of it has to be renewed whenever there is a thin place in it, the cost will be very much greater. I think, if I were you, I should not abandon the gannister lining till you have tried it further, and if you cannot altogether stop the action on it by adding silica; add to the life of your lining by putting an extra thickness of silica in it.

"Yours truly, "Arthur Cooper."

It will be seen that, although Mr. Cooper is not so confident that the action of the protoxide of iron will be mitigated to the extent I anticipate, yet he strongly recommends that a gannister lining should not be abandoned, and confirms my opinion, that if the conditions will admit of an acid slag being formed, the action of the oxide will be reduced very considerably. But, whether the lining should be siliceous or otherwise, I was pleased to find that in the opinions expressed at the meeting this was not considered an insuperable difficulty. As, however, it is a matter of importance, I trust my scientific and practical friends will continue to give me the benefit of their valuable advice thereon.

Taking now the seventh section of the summary, I wish to observe that Mr. Vivian's letter was only handed to me immediately before the opening of our meeting, I had thus but a few minutes for consideration, but I felt that such an expression of opinion from so eminent a copper-smelter should not be withheld from the meeting, even although I fully realised that this opinion would place me at a disadvantage.

With respect to Mr. J. Fenwick Allen's opinion that my process, though adapted for sulphides, had no applicability to ores consisting of silicates, carbonates, and oxides, I would venture to remind you that it was admitted to be correct that "iron being more oxidisable than copper, silver and gold, these latter will all be concentrated in the regulus, provided an excess of sulphide of iron is always present" (No. 2, "E"), and that "incombustible materials added to the charge may contain valuable metals as oxides, which will pass into the regulus or be volatilised as sulphides, after double decomposition with protosulphide present in the molten bath. Thus silicate of "copper would be converted into sulphide of copper and concentrated in the regulus ("J"), and also that the preceding propositions "H" and "I" are practically correct. Therefore, these points being admitted, I think it logically follows that my process is adapted for the treatment of every description of copper ores, whether oxides, carbonates, or silicates, provided sufficient iron pyrites be added to produce, by oxidation of the protosulphide of iron, the necessary temperature to obtain complete fusion of the regulus, and of the siliceous and other materials necessary to form a suitable liquid slag. It should not be overlooked that in the copper-producing countries where coal is costly, the poorer ores, now totally neglected owing to the cost of transport, could be profitably utilised by my process in their respective localities, provided that, if such ores do not contain sufficient sulphur, pyrites is available in the neighbourhood.

With reference to the estimates, as Dr. Graham very properly pointed out, I did not base my balance-sheet on the working with the inappropriate Bessemer plant employed for the experiments, but on the practical working when using plant and apparatus specially designed for the process, such as has been suggested by Mr. Howson and Mr. Blair. It should be observed that in my calculations I have not assumed any values for the sulphurous acid, or for the volatile metallic sublimates, although they will doubtless form important items of revenue.

I may also add that my estimates of the cost of the process have been made with liberal allowances for contingencies, and have been based on calculations confirmed by Mr. Blair and other practical men. These estimates are simply for the treatment of the poorest class of Spanish pyrites on the mines, and show a profit of 11s. a ton as compared with 1s. 9d. per ton by the present cementation system. It is, however, manifest that the benefit arising from the use of the process would be proportionably increased when the better class of pyrites, like that selected for importation to the United Kingdom, is treated.

The following is an extract from Mr. Blair's speech:—"I think it is a most inconvenient thing that there is so little difference between the specific gravity of his regulus and slag. The specimens you see on the table are perfectly well adapted for smelting in the blast furnace, containing, as they do, 40 or 50 per cent. of iron. But it is a most unfortunate thing he should be compelled to add other bases to decrease the specific gravity of the slag, thereby depriving the ironmasters of a very valuable bye-product." And the following is an extract of a letter which I have since received from Mr. Blair, dated 15th February, 1879:—"As to iron slag, a material of 30 per cent. or more iron, with suitable earthy bases, would still be marketable. It may pay you to aim at such a product. It would be useful to the manufacture of Bessemer pig." It will be observed that, as my calculations are based on working pyrites in Spain, I have not included in them any value for this bye-product; but with pyrites treated in this country it would form a valuable item of profit.

In reply to the suggestion that there might be difficulties in the collection of the sulphur and metallic sublimates, I hold that there should not be much difficulty, because it must be borne in mind that the gases present are much less in quantity than in ordinary metallurgical operations, where carbonaceous fuel is employed, and where an excess of air is required to obtain the combustion of the coal.

Professors Abel and Graham both considered it necessary that the process should be continuous and not intermittent; this I expect to obtain by adopting a modification of the ordinary blast furnace provided with tuyères suitably placed, so that the blast could be driven through the molten sulphides, and Mr. Howson and Mr. Blair, who are both practical men, assure me there is no reason why this cannot be done.

Mr. Blair thought that the gases ought to be allowed to pass off at a higher temperature than 500° or 600° C.; but, on the other hand, he considered this would cause a difficulty on account of the corrosive action of the sulphur vapour on the ironwork at that temperature. With a high furnace, so arranged as to draw off part of the gases at about 10 feet below the top, the sulphur and part of the anhydrous sulphurous acid and nitrogen could be withdrawn, and the remainder of the gases, after being cooled by passing upward through 10 feet of pyrites and fluxes, would pass off at a temperature

of about 140° C., and in this way the heat would be used in heating the charge, and in driving off any moisture introduced with the pyrites and fluxes.

I would now call your attention to the fact that, if this process were adopted in Spain, and it were found convenient to waste the sulphurous acid, the quantity of this deleterious gas would be reduced at least one half as compared with the present system; consequently, the injury to animal and vegetable life would be proportionately decreased. In the Estremadura, there exist large deposits of natural phosphates, and with a development of railway communication, which I understand is in contemplation, these phosphates could be brought at a moderate cost to the neighbourhood of the mines, for conversion into manures, in which case it would doubtless pay to oxidise the sulphurous acid in chambers in order to produce the vitriol required for the manufacture of the manures. In working the process in the United Kingdom, the sulphurous acid would certainly be thus converted into sulphuric acid, or otherwise utilised.

Mr. Thomas Hughes, who supposed that a patent taken out by Mr. William Keates was identical with mine, was corrected and explicitly answered by Mr. J. Fenwick Allen. Since the meeting I have had the opportunity of perusing Mr. Keates's patent, which is dated 4th September, 1856, No. 2,057, and he claims as follows:—"I claim the introduction of atmospheric air, whether artificially treated or at the ordinary temperature of the surrounding atmosphere, at a pressure obtained by mechanical means into and through or over the surface of the mass of melted regulus or matt containing copper. I also claim the use of furnaces constructed either of the form shown in the accompanying sheet of drawings or any other convenient form which combines the necessary apparatus or means for introducing the aforesaid currents for the purpose of desulphurising regulus or matt of copper."

From this it will be seen that Mr. Keates's patent was for "desulphurising regulus or matt of copper." Whereas my process is "a new application of rapid oxidation by which sulphides are utilised for fuel."

In conclusion, permit me to remind you that comparatively rapid oxidation may also be utilised in the reduction of even the more volatile metals. It is well known that the following reaction takes place, $PbS + 2PbO = 3Pb + SO_2$. If, therefore, a limited amount of air is blown into molten sulphide of lead, the oxide thus formed in the lower part of the furnace will, in passing upward, come in contact with the hot sulphide of lead and metallic lead will result with the evolution of sulphurous acid. If the furnace has a quiescent hearth below the tuyères, the metallic lead will collect there, and can be from time to time withdrawn. I have said a limited amount of air because it must not be driven in too rapidly, otherwise the sulphide of lead would rapidly distil off. In thus treating argentiferous lead ores, the silver (and gold, if present) would be found with the first metallic lead produced. When thus treating galena the furnace should have a basic lining. The process is peculiarly suitable for the treatment of mixed ores, whether sulphides or oxides, because each metal or compound has a particular temperature at which it volatilises, and therefore the process may be described as fractional decomposition, the heat being entirely obtained by oxidation of the metals or metallic compounds.

John Hollway.

London, 20th February, 1879.

I shall be glad if you can allow me space for a little further explanation in addition to the remarks of mine on Mr. Hollway's process as reported in the last number of the *Journal*.

The principal object of my first speech was to show how improbable it was that any free oxygen would get through the layer of molten sulphides during the process of blowing. In illustration of this, I mentioned the fact that the current of ascending gases in the blast furnace is entirely deoxygenated within a few inches of the tuyères, and this although the materials contain only some 25 to 30 per cent. of combustible matter. Now in the Hollway process we have about three times as large a proportion of combustible matter, and the air has every opportunity of parting with its oxygen as it bubbles up through the molten mass. The fact that the converter is filled with brown sulphur vapour, which burns with a large blue flamo on reaching the mouth, shows clearly that oxygen is not in excess. If there be any tendency to incomplete absorption of the oxygen, it can always be obviated by reducing the pressure of the blast.

With respect to the calorific power of the molten sulphides, and the probable temperature produced by their oxidation, I would point out that Mr. Hollway has formulated the main reaction as follows:—

$$5FeS_2 + 12O = FeS + 4FeO + 4SO_2 + 5S,$$

that is, that half the sulphur of the pyrites is distilled off in a free state, while 40 per cent. burns to sulphurous acid, and 10 per cent. remains in the regulus. The heat evolved by the combustion of sulphur in one gramme of oxygen is 2,220 units, and by the combustion of iron, 4,478 units. Hence, in one sense, the combustion of iron may be said to produce twice as much heat as the combustion of sulphur. But the above formula shows that twice as much oxygen combines with the sulphur as with the iron of the materials, and hence, in practice, the oxidation of the sulphur evolves as many units of heat as that of the iron. Still, we must not regard the heat as being produced simply by the combustion of sulphur, for the above considerations show that an equal quantity is due to the oxidation of the iron.

The combustion of carbon to carbonic oxide involves 2,473 units of heat per unit of carbon oxidised, or 1,855 per gramme of oxygen employed. In the lower part of the blast furnace the carbon is burnt chiefly to carbonic oxide, only a small proportion being oxidised in a more advantageous manner to carbonic acid. On burning to carbonic acid, carbon evolves 8,080 units of heat per gramme of carbon used, or 3,030 units per gramme of oxygen consumed.

By the oxidation of protosulphide of iron (FeS) we obtain—

$$\frac{2220 \times 2 + 4478}{3} = 2973 \text{ units of heat}$$

for each gramme of oxygen consumed, or nearly the same amount of heat as we should obtain by the complete combustion of as much coke as could be burnt in the same quantity of air.

In the above calculations no account is taken of the absorption of heat consequent on the decomposition of the sulphide of iron. Taking this as equal to that evolved by the combination of iron with sulphur to form FeS, which is 634 units per gramme of iron, we obtain 431 units to be deducted from the calorific power of 1 gramme of FeS, or 235 units per gramme of oxygen used. This leaves 2,738 units as the calorific power of the sulphide oxidisable by 1 gramme of oxygen, which is not much less than the heat produced (= 3,030 units) by the oxidation of carbon to carbonic acid by an equal weight of oxygen. The calorific values of equal weights of protosulphide of iron and of carbon, when completely burnt, are as 5020 and 8080, but if the carbon be burnt to carbonic oxide only, as happened in the blast furnace and the Bessemer converter, the proportions are as 5020 to 2473, or roughly, as 2 to 1.

It is, perhaps, the fairer way to make the comparison of the units of heat evolved by the action of equal weights of oxygen, when acting on the sulphides and on carbon respectively, as in practice the amount of air

blown through the materials is the true measure of the chemical change effected.

In these calculations I have purposely omitted any consideration of the heat absorbed in decomposing the pyrites, and volatilising the second atom of sulphur, as Mr. Hollway proposes in practice to effect this in the inclined part of the converter by the heat of the sulphurous gases. Hence the whole of the heat generated in the converter will be available for heating and fusing the earthy matters employed as fluxes and contained in the ore, and for raising the gases to a proper temperature. ALFRED H. ALLEN.

1, Surrey-street, Sheffield, February 18th, 1879.

OBITUARY.

Mr. Bennet Woodcroft, F.R.S.—Mr. Bennet Woodcroft, whose name was so long connected with the Patent-office, died on Friday, the 7th instant, in the 76th year of his age. Mr. Woodcroft was born at Stockport, in 1803. After practising for some years in Manchester as a consulting engineer and patent agent, he came up to London, a few years before the passing of the 1852 Patent Act, to carry on the same business. From 1847 to 1851 he held the post of Professor of Machinery at University College, but, possibly because the want of Technical Education was not then generally acknowledged, the class was not very successful. In 1852, Mr. Woodcroft was appointed to the Patent-office, first as Superintendent of Specifications, and then as Clerk to the Commissioners of Patents. The indexes of the old Law Patents, which he had prepared for his own use, were purchased by the Government, and continue, up to the present date, the only indexes existing. It was owing to Mr. Woodcroft's exertions, and under his directions, that the old Patent Specifications were printed, a task the various difficulties of which may be less obvious now than they appeared to those then concerned in the undertaking. The admirable library of the Patent-office was established by Mr. Woodcroft, as was also the less fortunate Patent-office Museum. At the outset there were certain disagreements between the South Kensington Museum authorities and those of the Patent-office, and the idea was never developed as it was hoped it might be. The best tribute to the value of Mr. Woodcroft's work is to be found in the fact that much of it has been copied—to a greater or less extent—in other countries, as in the United States and in our own colonies. He was the author of various works; among others, "A Sketch of the Origin and Progress of Steam Navigation," and "Biographies of Inventors of Machines for the Manufacture of Textile Fabrics." In 1852, he contributed a paper on "Steam Navigation" to the volume of the Society's "Transactions" which preceded the establishment of the *Journal*. He patented several inventions referring to steam navigation, spinning, and dyeing, the best known of these being perhaps his screw propeller with increasing pitch. He became a member of the Society in 1845, and continued till 1858. Mr. Woodcroft retired two years ago on a pension.

GENERAL NOTES.

London Society for the Extension of University Teaching, 22, Albemarle-street, W.—This Society, which was formed in 1876, has been at work since the autumn of that year, but it is only this winter that its organisation has been fully completed by the formation of a joint board of nine, composed of three representatives from each of the Universities of Oxford, Cambridge, and London, who will nominate the society's teachers and examiners, grant certificates of examination, and advise the council generally. A public meeting, to make known the completion of the society's scheme, and to invite support of it, was held at the Mansion-house, on Wednesday, February 19th, at 3 p.m., the Lord Mayor in the chair. Prince Leopold, Mr. Gladstone, Mr. Goschen (president of the society), and representatives of each of the three Universities attended.

Old London Crace Collection.—The collection of maps, plans, and views of London and Westminster made by the late Mr. Frederick Crace, and lent to the South Kensington Museum by his son, Mr. J. G. Crace, is now on view from 10 to 4 daily in two of the upper rooms, in the galleries on the west side of the Horticultural Gardens. These rooms, which are lent to the Museum by her Majesty's Commissioners for the Exhibition of 1851, were for a time devoted to the Caxton Exhibition. They may be reached either by the entrance in Queen's-gate or by that in the Exhibition-road immediately facing the main buildings of the museum. Admission is free on Monday, Tuesday, and Saturday; on the three other week days on payment of sixpence. Visitors to the South Kensington Museum may pass to these galleries without further payment. The plans and views selected from the collection for exhibition are 3,085 in number. A complete catalogue, compiled from Mr. Crace's larger work, has been issued by the Stationery-office at sixpence, and may be purchased in the museum.

Industrial Home Orphanages.—A correspondent requests that any prospectuses of such institutions may be sent to H. C., at the Society of Arts, John-street, Adelphi, London, W.C.

NOTICES.

THE LIBRARY.

The following works have been presented to the Library:—

A Practical Treatise on Warming Buildings by Hot Water, Steam, and Hot Air, and on Ventilation, by Charles Hood, F.R.S. (Lond., Whittaker and Co., 1879.) Presented by the Author.

Art Union of London, Reports for 1839-44, 1849-52, 1856, 1862, 1878. (Lond., 1877-78.) Presented by the Council.

Science for All. Vol. 1. (Lond., Cassell, Peter, and Galpin.) Presented by the Publishers.

The Principles of Light and Color, by Edwin D. Babbitt. (New York: Babbitt and Co., 1878.) Presented by the Publisher.

The Water Supply of Sea-side Watering Places, by G. W. Wigner, F.C.S. (Lond., Kent and Co., 1878.) Presented by the Author.

Universal International Exhibition (Paris), 1878. Report on the Exhibits connected with Materia Medica, Pharmacy, Chemical Industry, &c., by B. H. Paul, Ph.D., E. M. Holmes, F.L.S., and F. Passmore. (Lond.: Privately Printed, 1878.) Presented by the Reporters.

The Fuel of the Sun, by W. Mattieu Williams, F.C.S. (Lond.: Simpkin, Marshall and Co., 1870.) Presented by the Author.

Paris Universal Exhibition of 1878, Handbook to the British Indian Section, by George C. M. Birdwood, C.S.I., M.D. (Lond., Offices of the Royal Commission.) Presented by Dr. Birdwood.

The following pamphlets have also been presented to the Library:—

Revised Guild Action. Suggestions to the Wardens and Court of Assistants of the Worshipful the Company of Plumbers, by George Shaw, Master. (Lond., 1878.) Presented by the Author.

Cast Iron Pipes, by E. Benedict. (Lond., E. and F. N. Spon, 1878.) Presented by the Author.

A Survey of the Carriages at the Paris Universal Exhibition, 1878, by G. N. Hooper. (Lond., 1878.) Presented by the Author.
The Hill Country of Alabama, U.S.A., or, the Land of Rest. (Lond., E. and F. N. Spon, 1878.)
Remarks on the Electric Light, by H. M. Backler. (Lond., Printed for Private Circulation, 1878.)

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock :—

February 26.—"Indian Pottery at the Paris Exhibition." By George Birdwood, Esq., M.D., C.S.I. Sir Philip Cunliffe Owen, C.B., K.C.M.G., will preside.
March 5.—"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By Joseph J. Pope, Esq., M.R.C.S., L.S.A.
March 12.—"The Compensation of Watches, Clocks, and Chronometers." By Edward Rigg, Esq., M.A.
March 19.—"Economical Gardens for Londoners." By W. Mattieu Williams, Esq., F.R.A.S., F.C.S.
March 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor Barff, M.A.
April 23.—"English Fresh-water Fisheries." By J. Willis-Bund, Esq., Chairman of the Severn Fishery Board.

African Section.

Tuesday Evenings, at Eight o'clock.

March 18.—"Africa, a Paramount Necessity for the Future Prosperity of the Leading Industries of England." By James Bradshaw, Esq., of Manchester. Sir T. Fowell Buxton, Bart., will preside.
After the reading of Mr. Bradshaw's paper there will be a general discussion on the various schemes that have been proposed for the introduction of trade and civilisation into the interior of Africa.
April 1.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.
April 29.—"Some Remarks upon an Old Map of Africa contained in Janson's Atlas, published at Paris in 1612." Communicated and exhibited by R. Ward, Esq.

Chemical Section.

Thursday Evenings, at Eight o'clock.

March 13.—"The Injurious Effects of the Air of Large Towns on Animal and Vegetable Life, and on Methods Proposed for Securing Salubrious Air." By W. Thomson, Esq., F.R.S.E.

Indian Section.

Friday Evenings, at Eight o'clock.

March 7.—"The Plants of India adapted for Commercial Purposes." By John R. Jackson, Esq., Kew Museum.

Cantor Lectures.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Dwelling-houses: their Sanitary Construction and Arrangements."

Lecture II.—February 24.
Ventilation, Warming, and Lighting.—Size of rooms, overcrowding, ventilators, stoves, lights, &c.

Lecture III.—March 3.
Water Supply.—Sources, systems of service, cisterns, pipes, filters, &c.

Lecture IV.—March 10.
Removal of Refuse Matters.—Dust, kitchen refuse, earth-closets, &c. Conservancy and water-carriage systems compared.

Lecture V.—March 17.
Sewerage.—Main sewers and house branches, traps, ventilation, &c.

Lecture VI.—March 24.
Water-closets, Sinks, and Baths.—Arrangements of pipes, traps, &c.

N.B.—The Course will be illustrated by specimens and models from the Parkes Museum of Hygiene.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. W. H. Corfield, "Dwelling Houses ; their Sanitary Construction and Arrangements." (Lecture II.)
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. 1. Mr. Clements R. Markham, "The Basin of the Helmund." 2. Lieut.-Gen. E. Kaye, "The Mountain Passes Leading to the Valley of Bamian."
British Architects, 9, Conduit-street, W., 8 p.m. 1. Discussion on Mr. Pennethorne's paper, "The Connection Between Ancient Art and the Ancient Geometry as Illustrated by the Works of Pericles." 2. Mr. James K. Colling, "Architectural Foliage."
Institute of Actuaries, The Quadrangle, King's College, W.C., 7 p.m. Mr. E. Smyth, "Tables for the Enfranchisement of Copyholds of Inheritance."
Medical, 11, Chandos-street, W., 8.30 p.m.
London Institution, Finsbury-circus, E.C., 3 p.m. Prof. H. E. Armstrong, "Modern Chemical Theory."

Tues....Metropolitan Scientific Association, 160a, Aldersgate-street, E.C., 7 p.m.
Royal Institution, Albemarle-street, W., 8 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture VII.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Discussion on "The Construction of Heavy Ordnance."
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Mr. C. Staniland Wake, "The Primitive Human Family." 2. Mr. E. W. Brabrook, "Notes on the Colour of Skin, Hair, and Eyes."

Wed. ...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Dr. George Birdwood, "Indian Pottery at the Paris Exhibition."
Geological, Burlington-house, W., 8 p.m. 1. Mr. G. W. Shrubsole, "A Review of the British Carboniferous Fenestellidæ." 2. Prof. H. G. Seeley, "Note on a Femur and Humerus of a small Mammal from the Stonesfield Slate." 3. Mr. J. W. Hulke, "Note on *Poikilopleuron Bucklondi*, of E. Deslongchamps, père, identifying it with *Megolosaurus Bucklandi*." 4. Mr. J. W. Hulke, "*Vectisaurus valdensis*, a new Wealden Dinosaur."
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Mr. Brabrook, "On an Unrecorded Event in the Life of Sir Thomas More."
Telegraphic Engineers, Broad Sanctuary, S.W., 8 p.m.

Thur....Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 7 p.m. B. Waterhouse Hawkins, "The Age of Dragons."
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Tyndall, "Sound." (Lecture III.)
Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.
Philosophical Club, Willis's-rooms, St. James's, S.W., 6½ p.m.

Fri......Royal United Service Institution, Whitehall-yard, 3 p.m. Mr. J. K. Laughton, "The Heraldry of the Sea; Ensigns, Colours, and Flags."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Sir William Thompson, "The Sorting Demon of Maxwell."
Quekett Microscopical Club, University College, W.C., 8 p.m. 1. Dr. Matthews, "A Mode of Displaying Objects by the Microscope Irrespective of their Size (the Micro-Megascope)." 2. Dr. C. T. Hudson, "The Rotifers by Dark Field Illumination, Illustrated by Transparencies."
Clinical, 53, Berners-street, W., 8½ p.m.

Sat......Royal Institution, Albemarle-street, W., 3 p.m. Mr. Reginald W. Macan, "Lessing." (Lecture IV.)

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FRIDAY, FEBRUARY 28, 1879.

All communications for the Society should be addressed, for the present, to the Assistant-Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

DEATH OF MR. LE NEVE FOSTER.

It is with the deepest regret that the Council have to announce to the Members the loss they have sustained by the sudden death of the Secretary of the Society, Mr. Le Neve Foster. During the long term of twenty-five years Mr. Foster has devoted his life earnestly and zealously to the service of the Society of Arts, and under his superintendence the Society has risen to its present state of prosperity. The Council feel that they have lost an efficient officer, a trusted adviser, and a valued friend.*

NATIONAL SCHOOL OF WOOD-CARVING.

With a view of encouraging the art of Wood-Carving in this country as a branch of the Fine Arts, a school, under the above title, has been opened at 3, Somerset-street, Oxford-street, W., as an experiment, for the teaching of Wood-Carving.

The Provisional Committee, consisting of Col. Donnelly, R.E., Mr. J. H. Donaldson, Mr. R. W. Edis, F.S.A., (the late) Mr. P. Le Neve Foster, and Mr. E. J. Poynter, R.A., have secured the services of the eminent Florentine artist, Signor Bulletti, to take charge of the classes.

Premises suitable for the purpose have been taken, for the rent of which Messrs. Gillow and Co., in aid of this national object, have liberally made themselves responsible. They will also supply the necessary plant and models, and a sufficient amount of work for a year, so that it is hoped that a permanent School of Art Wood-Carving may eventually be established.

The hours of attendance are, for day students, from 10 to 1 and from 2 to 5; for evening students, from 7 to 9.

Students are admitted on the following terms:—Day students, £2 a month, or £5 a quarter; evening students, 15s. a month, or £2 a quarter.

Students must provide their own tools, and work done in the school cannot be taken away.

The Council of the Society of Arts, aided by funds placed at their disposal by the Worshipful Company of Drapers for promoting Technical Education, select and pay the fees for six months of four day students, who must undertake to attend daily during the whole of that time from 10 to 1 and 2 to 5 *at least*; and of four evening students, who must attend from 7 to 9 *at least*. Candidates for these studentships must have passed the 2nd Grade Art Examination of the Science and Art Department in Freehand Drawing, at least. Those who have some knowledge of Wood-Carving, or have passed in other subjects of the 2nd Grade Art Certificate, or in drawing from the antique and the figure, architectural drawing, or designing, or in modelling, will be preferred.

Further particulars, as regards both paying and non-paying students, may be had on application to the Assistant-Secretary of the Society of Arts, Adelphi, London, W.C., or at the school.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference will be held in the Rooms of the Society of Arts, on Thursday and Friday, the 15th and 16th May, 1879, on National Water Supply, Sewage, and Health, the Right Hon. JAMES STANSFELD, M.P., late President of the Local Government Board, in the chair, assisted by the members of the Executive Committee:—Lord Alfred Churchill (Chairman of Council); Sir Henry Cole, K.C.B.; Colonel Sir E. Du Cane, K.C.B.; Captain Douglas Galton, C.B., F.R.S.; Mr. F. A. Abel, C.B., F.R.S.; Mr. T. W. Keates; Dr. Voelcker, F.R.S.; Mr. W. Hawes, F.G.S.; Major-Gen. F. Cotton, R.E., C.S.I. Papers relating to the above subjects will be read and discussed.

PROGRAMME OF PROCEEDINGS.

The Conference will meet each day at 11 a.m., and sit till 1.30, then adjourn till 2, and sit again till 5 p.m., and, if necessary, meet again at 8 p.m.

Thursday, 11 a.m.—Opening of the Proceedings by the Chairman.
Papers and Discussion.

Friday, 11 p.m.—Proceedings will be resumed.
Papers and Discussions continued.

* A brief memoir of Mr. Foster will be found on page 316 of the present number.

There will be an Exhibition of Mechanical and Chemical Apparatus in connexion with Water Supply, Treatment of Sewage, and Health. All articles for exhibition must be delivered, carriage free, not later than Saturday, the 10th May, 1879. Manufacturers and others desiring to exhibit should communicate forthwith with the Assistant-Secretary of the Society of Arts.

Papers on any of above heads are requested.

The object of the Conference is to discuss existing information in connexion with the results of any systems already adopted in various localities, referring to the subjects of National Water Supply, Sewage, and Health; to elicit further information thereon; and gather and publish, for the benefit of the public generally, the experience gained. The introduction and discussion of untried schemes will, therefore, not be permitted. The papers accepted for the Conference will be printed and circulated at the Meetings.

The Council of the Society of Arts have determined to offer the Gold Medal of the Society, and three silver medals, for the best suggestions, founded upon evidence already published, for dividing England and Wales into watershed districts, for the supply of pure water to the towns and villages in each district.

The suggestions must be sent in to the Society's office, on or before the 26th April, so as to be discussed at the Conference.

The details of the conditions will be issued immediately, and may be had, when ready, on application to the Assistant-Secretary of the Society.

REPORT ON LIFE-SAVING APPARATUS.

Committee.—Lord Alfred Churchill (Chairman of the Council); Mr. T. Brassey, M.P.; Mr. Donald Currie; Admiral M. Nolloth; Admiral Sir Erasmus Ommanney, C.B., F.R.S.; Captain G. E. Price, R.N., M.P.; Admiral A. P. Ryder; Admiral Sir E. Sotheby, K.C.B.; and Captain H. Toynbee.

The circular which was issued on the 10th April, 1878, and which is to be our guide in making the award of the Gold Medal for Life-saving Apparatus, has thrown upon us the duty of considering—

First.—The vessels of various descriptions exposed to the danger of sinking at *very short* warning, viz., a few minutes.

Secondly.—What are the articles (if any) in vessels of each class which are already permanently buoyant, or can be made so, and would be sufficiently handy and numerous to act as life-saving apparatus, and to *float* all hands when the warning to abandon the ship has to be acted on promptly, viz., in a few minutes, and what are the best means of rendering them buoyant?

Note.—We use the word "*float*" advisedly, as the whole circumstances of the case point to the conclusion that this is all that can be provided for.

Thirdly.—Which (if any) of the other life-saving apparatus submitted to us are suitable to each class of these vessels (exposed to sinking at very short notice), supposing that the appliances already on board, and that could be made permanently buoyant, are for any reason not yet so treated?

Fourthly.—Whether there are among the appliances sent in, any which in our opinion not only possess the "qualifications" laid down for our guidance, but stand out so pre-eminently superior to the rest, that we can propose to the Council of the Society of Arts that they should *award their Gold Medal* to the exhibitor.

Fifthly.—Whether there are any other "exhibits" or any "communications" deserving *special commendation* or remark.

Sixthly.—Whether there are any experiments to be recommended for trial hereafter.

We have, of course, assumed that there can be no possible objection to every vessel, from the largest ironclad to the smallest yacht, being supplied with life-saving appliances sufficient to *float* every individual on board, when the vessel has to be abandoned at the shortest warning (a few minutes)—an event not unlikely to be of future frequent occurrence—provided that, in terms of the circular, these appliances:—

(1.) Do not occupy valuable space; do not interfere with the stowage of more important articles; are not in the way, are not unsightly, are ready at hand, and require little or no fitting when brought into use;

(2.) Are not unwholesome;

(3.) Are neither uncomfortable nor inconvenient to the seamen;

(4.) Have each a buoyancy of at least 40 lbs. and are sufficient in numbers for all hands;

(5.) Utilise, if possible, articles already on board;

(6.) Are either of no extra expense, as when substituted for an equally expensive non-buoyant material, or of moderate expense, both as to first cost and annual repair;

(7.) Are not affected by variations in climate, nor liable to injury from ordinary rough treatment.

We dismiss at once, as unworthy of consideration, any objection on the score of a fear that the supply of such buoyant articles would lead to premature abandonment of ships. We feel confident that the few persons who may have adopted this view, when considering the question for the first time, will, on reflection, be prompt to abandon it as untenable and unworthy of the men, whether sailors or soldiers. We feel assured, and have entered on this inquiry with the firm belief, that, if suitable means be devised by the Admiralty and the Board of Trade, they will be adopted, and the men carefully trained in their use.

The vessels of various description liable to be abandoned at short notice may be thus classed:—

I.—Men-of-War.

(1.) Of the *Ordinary Type*, whether wooden or ironclad, rigged or not, carrying *no* passengers.

(2.) *Troop Vessels*, carrying a small crew and a very considerable number of soldiers, with some

wives and children, the total number amounting in the large troop-vessels to 1,700.

Merchant Ships.

(1.) *Ordinary Merchant Ships*, whether steamers or sailing ships *without* passengers.

(2.) *Passenger* (*Emigrant*, *&c.*) *Ships, Sea-going.*

N.B.—The Peninsular and Oriental boats of 4,000 tons carry very few officers, *only six English seamen*, some Lascars, and several hundred passengers.

(3.) *Passenger Ships on Rivers*, carrying a very small complement of seamen, and frequently a great number of passengers.

N.B.—The *Princess Alice*, with over 800 passengers, was lately lost in the Thames, there being only a few survivors.

(4.) *Yachts, Barges, &c.*

The Council, by excluding from our consideration, *as regards the bestowal of the Gold Medal*, all rafts and boats, also life-belts with a less buoyancy than 40 lbs., has much facilitated our work, and made it more likely to be useful.

We recognise a distinct advantage, for this special service, in each of the life-saving articles (if there be at least 40 lbs. of buoyancy for each person on board), being of a buoyancy and general capacity for *floating* not more than *two* persons, and for this reason—*larger* buoyant articles would induce more persons to hold on and cling to them than they were calculated to float efficiently; and would perhaps tempt persons to get *upon* them, thus sacrificing buoyancy (see note to Table at p. 302); whereas if it were thoroughly understood and illustrated by a frequent rehearsal that while the buoyant article was intended to *float* one person yet was *capable* of floating two, but two *only*, a great deal of confusion would be avoided; moreover, two persons could readily communicate with each other, and agree to swim towards the land or the nearest ship, supported by their life-saving article.

Having carefully considered the circumstances attending the sudden loss, at a few minutes' warning, of various vessels of the above classes, we found that only a very small number of the "exhibits" were qualified under the "instructions" in the Council's circular to compete for the Gold Medal. We have recommended one person for the award of the Gold Medal. We have recommended for "honourable mention" numerous articles and suggestions showing, in various degrees, great ingenuity, considerable thought and zeal, and an unsparing readiness to expend money on models.

We had, as regards vessels of each class, to ask, as has already been seen—*Have they any articles ready at hand with sufficient capacity, and suitable in every respect to our purpose* (see the "Qualifications"), *which are already buoyant, or if not yet made buoyant, can be durably made so sufficiently to support one or two persons with their shoulders out of the water?* Bearing this in mind, we—in accordance with a very generally expressed public opinion—believe that:—

I.—Men-of-War.

(1.) In the *Ordinary Man-of-War*, whether iron-clad or wooden, rigged or not, *without passengers* the readiest, and by far the most efficient, means of *floating* all the crew, at the shortest warning, with a reasonable prospect of saving them, when other ships or land are near, will be afforded by—

Buoyant Hammocks.—In men-of-war the hammocks are sent on deck every morning, and stowed in nettings (or hammock boxes), in order to be out of the way and to increase ventilation below. In the tropics about one-third, viz., those of the watch on deck, are in the nettings throughout the night. There is one hammock for each man and each subordinate officer, and its shape admits of its being easily secured around the body. Buoyancy can be given to the hammock and berth mattresses by various substances—*air*, *sola* (a plant), *pith*, *deer-hair*, *seaweed*, *cork*, *&c.*

Each hammock with a buoyancy of, say 50 lbs., derived from one or other of these materials, would float one, or even two persons; and if a supplementary buoyancy (see the "waterproof" coverings suggested by various exhibitors and "honourably mentioned" at p. 301, Nos. (1) and (3) can be given, even although not of a permanent character, yet by its aid an additional person may be floated for a considerable time, provided caution be exercised not to unnecessarily immerse the hammock; and thus means of flotation for all hands would be supplied by the "watch on deck's" hammocks.

If, however, there were time sufficient to "lash up" the hammocks below, the available buoyancy would be trebled; and even if there were not time to "lash up," and thus secure this supplementary buoyancy, but only to take the mattresses out of the hammocks, yet a large increase in the total supply of buoyancy would be secured. Mattresses ought therefore to be fitted with hinges and straps, so as to be available for use without the hammocks (see page 300).

The *berth* mattresses for officers who have cabins would, of course, be made buoyant as well as those of the seamen's hammocks, of whatever nature the stuffing chosen, and be fitted with hinges and straps.

We have satisfied ourselves, by personal inspection, not only that there is no difficulty in having one side of the buoyant mattress stuffed with good horse-hair, so as to secure its being as comfortable, or nearly so, as if the mattress were entirely stuffed with hair, but that there is a further advantage, if the buoyant material is cooler than hair, for then that side of the mattress would be slept on in hot, and the other in cool, climates.

We are informed that *hair* mattresses in hammocks in the tropics are frequently too hot to sleep on.

It is obvious that *all* the hammocks should be made buoyant or *none*.

A vessel-of-war has not any loose articles about the decks, as seats, cushions, &c.

The best article next to the *hammock* is the ornamental *gunwale moulding*, which if made of some light but strong material can be fitted conveniently in short sections to support two men, with a buoyancy of over 40 lbs. for each.

I. (2.) *The Troop Vessel.*—Here, in the largest, there is a small crew of perhaps 200 officers, seamen, stokers, stewards, &c., and, say, 1,000 soldiers, with numerous wives and children—1,700 in all. Whatever life-saving apparatus be adopted for the *crew* of *ordinary men-of-war* (for

instance, buoyant hammocks) should be carried in *troop vessels* for their small *crew*. In attempting to provide buoyant articles for the *soldiers*, or rather to render articles that are ready at hand buoyant, we are met with the fact, that a *soldier*, when embarked in a man-of-war troop vessel, has no mattress—only a hammock and one or two blankets, or he sleeps on a sloping mess-table, as on his guard-room bed on shore. There is no article that could be suitably utilised, except their *packs* (emptied of the clothes), which could be made buoyant. One of the "articles" exhibited is a "carpet bag" so treated; it is self-inflating, but entirely dependent for efficiency on a double *airproof* and *waterproof* lining, which not only adds to the weight, but would in all probability be found untrustworthy in very cold or hot weather.

We are, therefore, of opinion that there is only one way of meeting the case of *soldiers* in man-of-war troop-vessels, viz., to provide for each man a life-belt of the simplest description, not made *jacket*-fashion, which is necessary when men have to *row or work in their belts*, but in a much simpler form, distributing the buoyant article, whatever it may be, at the chest, the back, and under the armpits. The *amount* of buoyancy provided would be at the discretion of the authorities.

40 lbs. (which we recommend) would support a clothed soldier, his rifle, and 10 lbs of ammunition.

25 lbs. would enable a clothed soldier who could swim, to support a man or woman who could not.

20 lbs. would support a soldier in his clothes with shoulders out of the water.

The soldiers are in "messes" of 16. The life-belts, by whatever means their buoyancy be obtained, might be stowed on a narrow shelf against the ship's sides, in the messes, quite out of the way. The space occupied would depend upon the material used. "Exercise" and "stations" would enable the belts to be passed up to the upper deck by, say, two soldiers from each mess in a very short time.

Note.—One half of a cubic foot of good block cork has a buoyancy of about 25 lbs. and weighs about 6 lbs.; 16 of these belts belonging to one mess of 16 soldiers would (if of cork) occupy eight cubic feet of space, or if placed on a shelf one foot wide, would require 4 feet in length by two in height. If 40 lbs. of buoyancy were required in each of the soldiers' life-belts, then, assuming cork to be the material adopted, the space required, if the shelf were 16 inches deep, would be 4 feet in length and 34 inches in height. Two straps around would, under all circumstances, preserve the belts in their places until required.

II. Merchant Ships.

(1.) *Ordinary Merchant Ships* without passengers stand on the same footing, whether sailing or steam-ships, as the *ordinary men-of-war:* whatever articles already at hand, one for each man but *capable* of floating two men, are for the future to be made buoyant in men-of-war, should be similarly treated for the merchant seamen, so that for both cases the berth and hammock mattresses are the articles most suitable to the purpose. As it is not customary in merchant ships to lash up and stow the hammocks, it becomes of still more essential importance that their mattresses be fitted with hinges and straps for use *without* the hammock.

II. (2.) *Passenger* (*Emigrant, &c.*) *Seagoing Ships.*—In the steamers of some "Lines" there is a life-belt for each *passenger* in his *berth*. Whatever life-saving appliance is considered best for the *crew* in men-of-war will probably be the best for the *crew* in these ships. With regard to the *passengers*, the *buoyant berth mattresses* appear to be most suitable, because of the great buoyancy that can be given them; they should be fitted with straps, and with longitudinal hinges in order to raise the centre of buoyancy; a mattress *without* a hinge would (when fastened round the body) have its centre of buoyancy below the waist, and would probably do more harm than good; the mattresses are *already* on board, and have only to be made buoyant; *life-belts* would necessarily be an *extra* appliance. On deck, the round life-buoys, the chairs, stools, benches, seats, cushions, if made permanently buoyant, will all answer useful purpose in case of sudden emergency.

In emigrant ships a cork mattress with hair and with hinge and straps for each emigrant should be provided by the owners, under the inspection of a Government official.

II. (3.) *Passenger Ships on Rivers*, with a crew of very few seamen, and frequently many hundred passengers. These have no *mattresses*, but numerous *chairs, stools, benches, seats, cushions*, ready at hand; all these can be made permanently buoyant, and the gunwale itself can be made in sections, of buoyant materials. An Act of Parliament could require that the number of passengers carried should be limited to the number of articles, with our *desideratum*, 40 lbs. of buoyancy for each passenger, readily available on the upper deck; this is to be ascertained by frequent inspection of a Board of Trade official.

II. (4.) *Yachts, Barges, &c.*—These stand on the same footing as merchant ships with passengers.

The berth mattresses and the gunwale mouldings can be made buoyant; also the loose articles about the decks.

Materials.

Various buoyant materials have been submitted to us, and of some of them a remarkable amount of buoyancy is alleged; we mention the most noteworthy, viz.:—

(*a.*) *Pith*, from South Africa. Sent by Mr. Fynmore.

(*b.*) *Seaweed*, treated with a preparation to prevent absorption. Sent by Mr. W. Hely.

(*c.*) *Pains et Briquettes de Varech.* Sent by M. Labrousse.

(*d.*) *Moose-hair.* Sent by Mr. A. Wood, of Liverpool.

(*e.*) *Deer-hair*, and "a material resembling hair." Sent by Mr. Bryson, of New York, and so described by him.

Note.—The hair of *deer* is stated to owe its remarkable buoyancy to cellular structure.

(*f.*) *Sola* (a plant from India), very light. Sent by Captain Dicey.

(*g.*) *Cork*, both granulated and in "block." Sent by numerous persons.

(*h.*) *Air* in watertight covers, bladders, &c.

Note.—The sea-freight chargeable on many of these materials, as it would be levied on *bulk* and

not on *weight*, would immensely enhance the cost of the life-saving article, especially when from a considerable distance. If the material were compressible without injury to its elasticity and permanent diminution of its buoyancy, this disadvantage would not arise; but none of the articles referred to—*a*, *b*, *c*, *d*, *e*, *f*—possess this desirable quality.

To ascertain *exhaustively* the comparative merits of numerous buoyant articles would require a long course of experiments, and is not necessary to the carrying out of our task. The experiments to which we have submitted them have satisfied us that *cork*, both *granulated* and in *block*, is the safest, and, therefore, on the whole, the best of the buoyant materials for life-saving apparatus with which we are as yet acquainted. *Black cork* absorbs a little water after several hours' immersion; *granulated cork* absorbs more after the same number of hours; cork, although its buoyancy is diminishable, retains it sufficiently for the time required; and is compressible under any probable pressure. *Cork* is unobjectionable on sanitary grounds; is not injured by any extreme of climate; *black* cork stands well a considerable amount of ill-treatment even if left uncovered.

Mattresses stuffed with granulated cork have been in use for many years afloat and ashore; many persons prefer them to hair mattresses, and if one-inch thickness of horse-hair be added on one side of the buoyant cork mattress, as in one of the "exhibits," the comfort is said to be all that can be desired.

In condition No. 6 of the Council's circular we are directed to "give, in the competition, a preference to 'appliances' that are the least expensive as to first cost and annual repair." It is not easy to obtain from inventors and manufacturers trustworthy statements as to what would be the cost of the articles they exhibit, chiefly because they are not as yet aware of the exact cost of manufacture on an extensive scale, and must guess at its amount. It may, however, be interesting to state that, in accordance with the present market price of good block cork, buoyancy derived from it can be given to any article of the same or nearly the same specific gravity as water at the rate of about 8s. per 40 lbs. of buoyancy, which would, no doubt, be lowered by competition. Granulated cork, much cheaper per lb. than good block cork, has. of course, when used in a life-belt, to be enclosed in a strong canvas casing, which should be specially prepared by tanning to resist mildew; this brings the price per pound of buoyancy to nearly the same amount, viz., about twopence.

The supply of cork from the south of Europe is said to be inexhaustible. The freight is moderate.

Having arrived at the above conclusions regarding *what articles should be made buoyant* in each class of ships, and what *buoyant material* we should recommend, we are of opinion that, in each class of ships under consideration, the series of buoyant articles in the annexed Table, column IV., most completely fulfil the conditions laid down by the Council, and entitle the exhibitor, Mr. A. W. Birt to be recommended by us for the award of the Gold Medal.

We wish to make "Honourable Mention" of the following articles, arranged *alphabetically*:—

(1.) Mr. A. W. Birt's waterproof sheet, 8 ft. by 4 ft., made of stout calico (prepared with a compound of boiled oil and soap, &c.), to be interposed between the hammock and the Royal Naval cork mattress, to give a supplementary temporary buoyancy of (it is alleged) above 50 lbs., in addition to the 50 lbs. due to the cork. This would not utilise anything already on board, unless the Admiralty supply the crew with waterproof sheets for campaigning purposes, as is done in the army when campaigning in the tropics, or unless a stout waterproof sheet be used as a substitute for the hammock, as has been suggested by a naval officer.

(2.) Mr. Bryson's deer-hair.

(3.) Mr. A. Hely's waterproof bags. This is not, except in the case of his doubled hammock covers, utilising anything already on board.

Mr. Hely received, in 1854, the Society's Isis Medal for his waterproof cylindrical bags for saving life. We heartily welcome him after twenty-five years' similar efforts in the cause of humanity.

(4.) Admiral J. W. D. McDonald's ingenious canvas boats. They do not utilise anything already on board, as these boats could not be substituted for the ordinary boats.

(5.) Mr. Harry Newton's cork belts. They do not utilise anything already on board; he appends a very suggestive paper, which we hope he will publish.

(6.) The metal cylinders supplied to their boats by the South-Western Railway. They do not utilise anything already on board, and are liable to become corroded.

(7.) Mr. P. P. de la Sala's ingenious canvas boats. They do not utilise anything already on board.

(8.) Mr. J. W. Watt's proposal to have the wooden frames of the sleeping berths in passenger ships made so as to be easily detached from the bed-places, and, when joined together, to make small rafts by aid of his cork matresses. *Rafts* are excluded from competition for the Gold Medal, and even if we regard each *frame* as one passenger's "life buoy," we have to face the difficulty that there are generally two and sometimes three berths in each cabin, and it would be almost impossible for the passengers to extricate their berth-frames from under the mattresses in the short time stipulated, even if both were previously prepared in anticipation of the catastrophe.

If the conditions of our inquiry extended the warning to considerably more than *few* minutes, say half an hour, each "berth bed-frame" might, perhaps, be made very useful with previous "exercise" at "stations," to assist in *floating* the passengers and stewards; not, however, by converting the *frames* into rafts, if by this is implied that the whole of each person's body is to be out of the water; the bed-frames would not have nearly sufficient buoyancy for this, even when supplemented by Mr. Watt's cork *berth* mattresses.

"Exercise" and "stations" should be the rule in all ships, whatever be the life-saving articles supplied.

9. Mr. A. Wood's moose-hair.

An analysis of the articles submitted by exhibitors gives the following results:—

In 25 the buoyancy is derived from *Cork*.
,, 20 from *Air* enclosed in an india-rubber or painted cover.

THE SERIES OF BUOYANT ARTICLES (See Column IV.),

Considered by the Committee as Deserving of the Gold Medal and Worthy of General Adoption.

DESCRIPTION OF VESSELS.	Articles already on Board, which can, and should be, made Buoyant.	Buoyant Articles which are not at present supplied but should be.	The Series of Buoyant Articles which best fulfil requirements.	Its own weight out of water.	Its Initial Buoyancy, viz., the weight of iron that it will just float when first immersed after air has been excluded.	Surplus Buoyancy after six hours in smooth water, with 40-lb. iron weight attached	Buoyancy after being sunk for twenty-four hours in six feet depth of water.	Name and Address of the maker of this Series of Articles.
I.	II.	III.	IV.	V. lbs.	VI. lbs.	VII. lbs.	VIII. lbs.	IX.
I.—Men-of-War. 1. *Ordinary*, whether Ironclad or manned, rigged or not	Hammock and Berth Mattresses for the officers and men	...	The Royal Naval Cork Mattress for the Hammocks of subordinate officers and the men. Note—There is hair on one side	18	60	14	50	A. W. Birt, of the firm of J. and A. W. Birt, Dock-street, London Docks, maker of Life-Saving Apparatus for the Board of Admiralty, the Board of Trade, &c., &c.
			The Cork Berth Mattress for officers with cabins. Note—There is hair on one side	18	75	26	60	
	As supplementary—the Gunwale Mouldings	...	The Gunwale Buoy	85	255	215	240	
2. *Troop Ships*.........	Hammock and Berth Mattresses for the officers and men	...	The Royal Naval Cork Mattress for the Hammocks of subordinate officers and the men. Note—There is hair on one side	18	60	14	50	
			The Cork Berth Mattress for the officers who have cabins. Note—There is hair on one side	18	75	26	60	
		Life Belts with a buoyancy of 40 lbs. for every soldier, woman, and child	The Soldier's Life Belt, No. I., buoyancy 40 lbs., for each soldier, their wives and children	11	43	3	40	
	As supplementary—the Gunwale Mouldings	...	The Gunwale Buoy	85	255	215	240	
	Stools........................	...	The Buoyant Stool	14½	43	3	40	
	Benches.....................	...	The Buoyant Bench	59	170	130	160	
II.—Merchant. 1. *Ordinary*, Merchant *Ship* (Steam Ship or Sailing Ship), without passengers..................	Hammock Mattresses for the crew	...	The Merchant Seamen's Cork Mattress for their Hammocks or Berths	18	75	26	60	Note.—The entries in columns V., VI., VII., VIII. are supplied by Mr. Birt. We have tested them to the extent of satisfying ourselves that each article has at least 40 lbs. buoyancy after being sunk for 24 hours in six feet depth of water.
	Berth Mattresses for the officers and crew	...	The Cork Berth Mattress for the officers. Note—There is hair on one side	18	75	26	60	
	As supplementary—the Gunwale Mouldings	...	The Gunwale Buoy	54	170	130	160	
	Stools........................	...	The Buoyant Stool	14½	43	3	40	
	Benches.....................	...	The Buoyant Bench	59	170	130	160	
2. *Passenger Ships*, with a large number of passengers...	Hammock and Berth Mattresses for the officers and crew	*Note*—When Crews, as in the case of Lascars, have no Mattresses, Life Belts should be supplied	The Cork Berth Mattress for the officers. Note—There is hair on one side	18	75	26	60	
			The Merchant Seamen's Cork Mattress for the crew	18	75	26	60	
	Berth Mattresses for the passengers		The Cork Berth Mattress ...... Note—There is hair on one side	18	75	26	60	
	As supplementary—the Gunwale Mouldings		The Gunwale Buoy	54	170	130	160	
	Stools........................	...	The Buoyant Stool	14½	43	3	40	
	Chairs	...	The Buoyant Chair	15	43	3	40	
3. *River Passenger Boats*, with a large number of passengers	Stools........................	...	The Buoyant Stool	14½	43	3	40	
	Chairs	...	The Buoyant Chair	15	43	3	40	
	Benches.....................	...	The Buoyant Bench	59	170	130	160	
	Cushions	...	The Buoyant Cushion	10¾	54	8	40	
	Seats	...	The Buoyant Seat.................	22	53	13	50	
	Gunwale Mouldings ...	...	The Gunwale Buoy	54	170	130	160	
4. *Yachts*	Berth Mattresses	...	The Cork Berth Mattress ...... Note—There is hair on one side	18	75	26	60	
	Stools........................	...	The Buoyant Stool	14½	43	3	40	
	Chairs	...	The Buoyant Chair	15	43	3	40	
	Benches.....................	...	The Buoyant Bench	59	170	130	160	
	Cushions	...	The Buoyant Cushion	10¾	54	8	40	
	Seats	...	The Buoyant Seat.................	22	53	13	50	
	Gunwale Mouldings ...	...	The Gunwale Buoy	54	170	130	160	

Note.—The *Men's Tables* in men-of-war (including troop ships), assumed to be twelve feet by three feet, could easily be made buoyant. If block cork were attached under the table, so as to give the table a buoyancy (assuming that it has none of its own) at the rate of 16 men × 40 lbs. of buoyancy = 640 lbs. of buoyancy, about one-fourth of that weight, or 160 lbs. of cork, would have to be attached to it, or a thickness of under five inches, but we have not included the *tables* in the above list, column II., as their size would invite too many persons to cling to them. Nevertheless, if for any reason the *mattresses* are not made buoyant, nor *life-belts* supplied in troop vessels, the tables should be made buoyant as well as the benches, &c.

In 12 from *Air-tight* metal cases.
,, 3 from *Air* enclosed in bladders.
,, 2 from *Deer-hair.*
20 were rafts.
3 canvas boats.
51 miscellaneous.
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EXPERIMENTS.

It only remains to point out the one direction in which research may usefully be made and experiments tried, viz., providing a thoroughly satisfactory light and strong *covering*, both airproof and waterproof, so as to supplement the buoyancy of already buoyant materials, by retaining the air and excluding the water. Existing coverings are made *temporarily* airproof and waterproof by preparations of india-rubber, oil, paint, &c. Fabrics coated with preparations of india-rubber are not proof against the effects of climate or rough usage, are not easily repaired, and, compared with those coated with the Chinese and other preparations, are very heavy, and if of the same dimensions, expensive. The recipe for "waterproofing" stout calico, used by the Chinese, and which is perfectly efficient, alike in the hottest and coldest climates, is believed to be composed of boiled oil, 1 quart, soft soap, 1 oz., and beeswax, 1 oz.; the whole boiled until reduced to three-quarters of its previous quantity; but experiments are required to satisfactorily test the above proportions: "paint" soon cracks, and ceases to be impervious to water. The addition to the boiled oil preparation of some ingredient which would prevent all risk of spontaneous combustion, when bales of oiled goods are sent abroad, would be advantageous; but no objection on this account applies to the supply of waterproof sheets (prepared with boiled oil, &c.) for use in *ships*, as only those that are in the hammocks would be coated, and with them there would be no more risk than is incurred with the seamen's waterproof jackets; the small spare supply would be harmless calico sheets, not to be waterproofed until required. Boiled oil, soft soap, beeswax, are all articles of supply to men-of-war.

The recipe used by Mr. Berthon to render the canvas of his collapsing boats airproof and waterproof, and believed to be similar to that used in H.M. dockyards for hammock-cloths, has courteously been supplied to us by him; it is as follows: —To 6 ozs. of hard yellow soap add 1½ pint of water, and when boiling, add 5 lbs. of ground spruce ochre, ½ lb. patent driers, and 5 lbs. of boiled linseed oil.

For waterproofing *sheets*, the ochre should be omitted, as it adds to the weight, lessens the flexibility, and is unnecessary.

We have already said that, as a matter of course, in every description of vessel, from the largest ironclad to the smallest yacht, it would be well to supply means of *floating* the crew and passengers, even if floating be all that can be effected, in case of sudden disaster by collision, fire, wreck, &c., when the vessel has to be abandoned promptly, and either there is no time to get the boats ready —or there are not boats sufficient—provided that no sacrifice or great sacrifice of space be asked for, no expense, or great expense, incurred, and, as far as possible, existing articles be utilised. It having been stated that there are persons who would deliberately withhold, if they had the power, all means of individual flotation for the crews of men-of-war and troop ships; we have sought information on the subject, and have ascertained that it is (see Evidence attached to the Report of the Committee on Saving Life at Sea, c. 627, 1872) for the reason:—That the men, in cases where danger was imminent, would, without permission, or in defiance of orders, rush to the life-saving appliances provided for them, instead of exerting themselves to save their ships; and that the soldiers in troop vessels would, if seized by a panic, rush below for their life-belts, and make confusion worse confounded, instead of "*falling in*" on the deck, resigned to go to the bottom, as did the gallant soldiers in H.M.S. *Birkenhead*, in 1852—an incident which has become historical.

It is not our duty to enter into any argument combating this view. Some of those who hold it prefer not to admit it openly, but to advance to the front such statements as these—"It can't be done." "There is no space to stow these appliances." "They wouldn't save life in a *collision on a dark night, in a gale of wind.*" "It would be better to sink at once than be floating alive for several hours and have one's eyes picked out by the gulls," "The granulated cork, unless taken out of the ticking, won't dry quickly," Why, we ask, should it not be taken out, as would be the case with hair, when it has been wetted? "It's all very well for the men-of-war sailors of *other* nations to be provided (as in the case) with these life-saving appliances; English man-of-war sailors are different, they don't require them," &c., &c. Such are the remarks of a small minority of persons, many of whom are reticent as to the *real* reason of their opposition, viz., a rooted, but, as we believe, most mistaken distrust of the preservation of discipline among seamen and troops under the circumstances. They apparently would rather that there should be a repetition of the loss of life in cases similar to those of the *Bombay*, the *Orpheus*, the *Eurydice*, the *Kurfürst*, &c., than provide life-saving appliances, which, they believe, would afford too ready a retreat for the panic-stricken. A fire-brigade relies on its ladders to enable the men to retire from the roof of the burning building when it becomes absolutely necessary to abandon it; what support would await the proposal of a regulation that the ladders were to be removed as soon as the firemen reached the roof? What would now be thought of a general who proposed to burn his boats or blow up the bridges as he crossed them on invading an enemy's country? Moreover, in cases of fearful emergency, such as those contemplated, are not measures at once taken to stimulate the faltering loyalty to the common weal of any possible faint-hearted man—sentries over the boats with ball cartridge, &c.? Surely every page of our British shipwreck history forbids the utterance of the cynical *quis custodiet?*

If, however, it be still thought advisable by the naval authorities that in *war time* our men should for any reason have *no* means of individual flotation when their ships are reduced suddenly to a sinking state by the "enemy's fire," "ramming," "torpedoes," &c., the following question would still remain for consideration and decision, viz., "shall *no* means be provided in *peace time* for

floating all hands in future cases of sudden abandonment, owing to *collision, fire, wreck, capsizing*," &c.? So that, when told to "save *themselves*"—which was the last order issued on board H.M.S. *Eurydice*—there shall still be no other than the at present inevitable reply, "How, sir? By what means? None have been provided."

If the decision on this latter question were in favour of the men's chances of safety in *peace* time, the advocates of *not* making the hammocks buoyant could of course urge upon the naval authorities—and most consistently from their point of view, although most mistakenly from ours, that "*always on the breaking out of hostilities* the cork should be removed from the *mattresses* (leaving only the hair which is quite sufficient for comfort), also the waterproof sheets from the hammocks." If successful in their endeavour, which we deem impossible, one very important point would, notwithstanding, have been gained, viz., that—at all events in *peace* time—everything would have been done to secure as far as possible the more than ever valuable lives of our too few carefully instructed officers and drilled men from a risk which appears to be increasing in frequency and intensity.

If our "Report," pointing out the ease with which the object can be attained, should lead to the adoption of our recommendations, even if only during *peace*, it will be a subject of congratulation—the rest may follow in the course of time.

The following are a few cases of vessels belonging to some of the various classes named at pp. 4 and 5, which have been lost during the last few years, in some of which many hundreds of lives would, without doubt, have been saved by such appliances as "buoyant hammocks," &c.:—

(1.) H.M.S. *Bombay*, line of battle ship, burnt off Monte Video in daytime in 1864, in fine weather, when nearly all the marines and boys were drowned within sight of the remainder of the officers and crew lying off in overladen boats. Captain J. Wilson, R.N., now Commodore in Australia, then Commander of the *Bombay*, has repeatedly stated that, *had the hammocks been buoyant, all the marines and boys would have been saved.*

(2.) H.M.S. *Orpheus*, Commodore W. Burnett, lost in fine weather in the daytime, in 1863, with nearly all hands, on a *bar* in New Zealand. Had the hammocks been buoyant, most of the men would have been carried by the current through the surf to smooth water.

(3.) H.M.S. *Eurydice*, capsized in a squall in daytime, in 1878, near the land and other vessels. Only two men were saved, one had secured a cork life-buoy. Had the hammocks been buoyant, the men would have been ordered to draw their knives along the covers, and many hammocks would have been freed. A buoyant hammock has much more buoyancy than a life-belt. If the outer part of the netting be "housed," it will occasion a very slight delay: but "housing" is quite unnecessary when the nettings are properly made.

* We deem it advisable to draw attention to the fact that the boats in many passenger vessels and in most merchant ships (differing in this respect widely from men-of-war), are so secured at sea as to be practically unavailable in cases when the vessel has to be suddenly abandoned. The method of "securing the boats *for sea*" should occupy the attention of the Board of Trade Inspectors, as well as their dimensions, lowering apparatus, and seaworthiness; the facility of rendering boats *available* being of at least as great importance as their *efficiency* when disengaged.

(4.) The case of the German ironclad, *Kurfürst*, lost by collision in 1878, was similar to that of the *Eurydice* in the suddenness of the catastrophe, the shortness of the warning; it was in the daytime, in fine weather, and other vessels were close to; yet only a few were saved.

(5.) In the case of the *Northfleet*, in 1873, a merchant ship, full of passengers, sank when at anchor, after a collision at night; the warning was of about an hour, yet nearly all hands were lost.

(6.) In H.M.S. *Vanguard*, an ironclad, lost by collision in 1876 in smooth water and a fog; the warning was of little more than an hour; most fortunately, her sister ship with an ample supply of boats was close to.

(7.) In the *Princess Alice*, a passenger-boat with over 800 passengers, the warning was of less than five minutes; she was sunk by collision in the Thames on a fine night in 1878, and more than 600 lives were lost.

It is not a little remarkable that we have had, during the last few years, an example of almost every conceivable description of sudden disaster to ships involving fearful loss of life, *the former of which would have been diminished by life-saving appliances in every case*—(*a*) loss by fire, (*b*) on a *bar*, (*c*) by capsizing in a squall in daytime, (*d*) in a squall at night, (*e*) by collision in daytime, (*f*) by collision at night. In a future war we shall probably have not infrequently to promptly abandon vessels after "ramming;" also owing to fatal injuries from *torpedoes*.

Every sailor in the Russian Imperial and the Danish Royal Navy is supplied with a buoyant mattress. Our Admiralty will, it is hoped, adopt the same course, which will materially aid the French, German, and Spanish Commissions, lately appointed by these Governments, to decide on the best description of life-saving appliances. Admiral Porter, in an official report of the condition of the United States' navy, urges the authorities to introduce *cork mattresses* in the Government service.

The president of the Humane Society of the United States has pressed the matter upon the attention of the authorities of the United States' navy.

The Congress of the United States passed an Act obliging all steamers and passenger vessels to carry life preservers under a penalty for neglect of one thousand dollars. Our Board of Trade will, it is hoped induce Parliament to take action similar to that of Congress as regards merchant ships, especially passenger ships.

If this competition of life-saving apparatus, and our Report with the suggestions we have ventured to make, should tend in any way to promote the very important object the Society of Arts has in view, it will afford much satisfaction to your committee.

(For the Committee),

P. Le Neve Foster, Secretary.

TWELFTH ORDINARY MEETING.

Wednesday, February 26th, 1879; Sir Philip Cunliffe Owen, C.B., K.C.M.G., in the chair.

The following candidates were proposed for election as members of the Society:—

Maxse, Rear-Admiral F. A., the Chestnuts, Wimbledon-common, S.W.
Reid, Frederick William, 79, Queen-street, Cheapside, E.C.
Reid, George, 79, Queen-street, Cheapside, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Beardmore, William, Portishead Forge and Rolling Mills, Glasgow.
Crawley, George Baden, 5, Albany, Piccadilly, W., and Wyvenhoe, Wilbury-road, Brighton, Sussex.
Fairweather, James G., C.E., 12, Buccleuch-place, George-square, Edinburgh.
Greig, John A., 93, Downs-park-road, Lower Clapton, E.
Harborow, Henry Arthur, 4, Circus-street, Marylebone-road, W.
Hooper, John P., The Hut, Mitcham, Surrey.
Horne, Edgar, 10, Woburn-square, W.C.
Howard, William Dillworth, Lordship-lane, Tottenham.
Mackay, Alexander, Trowbridge.
White, John Bazley, 7, Park-square West, Portland-place, W.

In opening the proceedings,

The Chairman said—Before I call on Dr. Birdwood to read his paper, I think it is only proper that I should remind you of the great void that has arisen in this Society since the last time you met. On Wednesday last my honoured friend, with whom I have lived for many years on terms of intimacy, was present here, and I had looked forward with much pleasure to his assistance and support in this duty which I am now undertaking for the first time. I think it is impossible for any man to have lived a life of greater public utility than our revered friend, the late secretary of this Society, Mr. Peter Le Neve Foster. He was one of those men who lived to do good and to render service to others. He had a large and generous heart; he had a bright intellect, and an intelligence that enabled him to bring this Society to its present state of prosperity. I consider his loss as really a public loss. He was not a man who sought to be talked about, but he sought rather to do good, wherever it came before him; and how much has that man been able to do during the 25 years that he held the post of secretary to this institution! I therefore, do think, ladies and gentlemen, the first duty that we have to perform here is to express our feeling of sorrow and our sympathy for the widow and family he has left. But I think that there is even a higher duty left to us, to see if we are not able to do something to prove the feelings of respect, and regret, and admiration that we have for the conduct he has pursued for so many years. You are all of you aware that at his advanced age—and many who were in the habit of seeing him every day could hardly believe, from his great activity, that he had reached such an advanced age—it was felt that the moment must arrive when he would have to retire, and many of us have had pleasure in subscribing to a testimonial in honour of a man whom we all respected. He has not lived to receive this testimonial, and it is therefore open to those who have taken part in it, and who may hereafter take an opportunity of joining, to largely increase it, and thereby show their respect for him, and provide a lasting testimonial for his wife and children. I trust that not only will this testimonial be presented, but that some public notice may be taken of the services which Mr. Foster has certainly rendered to his generation in the particular post he has occupied. He has been many years before the public, and no great public object has ever been taken up, no scheme for the good of the people, or for the good of mankind generally, has ever been started during the last 25 years but the honoured name of Peter Le Neve Foster was connected with it. Whenever there was anything to be done for the good of any class, or whenever anybody wanted advice, the person always referred to was Mr. Foster. It was to him everybody went, whether Englishman or foreigner; I have done so myself scores of times, and I have known many instances in which he has done an immense deal of good. I wish it had been the duty of some one more able than myself to express our sense of his loss. I was greatly shocked at the sudden removal of my friend, and that must be my excuse for any difficulty in expressing what I feel with regard to the great loss which this Society, and the public generally, have experienced in the sudden death of Mr. Peter Le Neve Foster.

Mr. Wm. Botly, as an old member of the Society, desired to support what the Chairman had said, and to speak from his personal experience of Mr. Foster's great services in connection with the Exhibitions of 1851 and 1862, and especially at the Paris Exhibition of 1867, where also, on the occasion of the visit made by the members of the Society to Paris, Mrs. Foster most gracefully performed those duties in which a lady could take part.

The paper read was—

INDIAN POTTERY AT THE PARIS EXHIBITION.

By George Birdwood, M.D., C.S.I.

It is not possible to mention the Paris Exhibition, and not to give expression to the pleasure and pride every Englishman must have felt in the British Section for the evidence it afforded of the national energy and patriotic spirit, and of our advancement in almost every branch of manufacture. One has but to mention the names of Minton, Wedgwood, and the Worcester Company, to know that the reputation of this country for porcelain and glazed earthenware was well sustained; but in looking at their exhibits in detail it was delightful to find the decided improvement that has been made in them even since 1871. The forms and mouldings of the pieces shown were more varied and refined than at any previous exhibition, and the drawing and painting more vigorous and artistic. The vases from the State factory at Sèvres were cast in grander proportions, but in no other quality of art did they show any superiority, and this was strained; while, for the exquisite grace and delicacy of treatment of the innumerable smaller articles in china, which contribute to felicity of our homes, the English manufacturers beat all other European competitors out of the field. The modelling of the Doulton ware generally, and the fountain in particular, were most admirable. The artist of Webb's beautiful carved and sculptured glass vases also deserves the highest commendation, for nothing so skilful has been done in this way since Josiah Wedgwood reproduced the famous Portland vase; and Powell's glass, for its characteristic lightness, quaintness, and fine colour, and above all its simplicity and purity, pleased me as much as any thing in the Exhibition. When I visited Paris in May, I only saw the glass and china, and the houses in the "Street of Nations." The furnishing of the Prince's pavilion, by Gillows, was in a high degree artistic, and the cabinets exhibited by Messrs. Jackson and Graham, who gained the *grand prix*, were certainly the greatest marvels of workmanship in the Exhibition. Messrs.

Collinson and Lock's house, furnished complete from top to bottom, was certainly one of the best successes of the Exhibition. The things put into it no more than furnished it, and represented their every-day work, which has always been specifically distinguished by its originality, variety, and scholarly treatment throughout. Their house, designed by Mr. Collcutt, was an excellent specimen of English country domestic architecture, devoid of all conceits, sensible in every part, and perfect in repose. It was unfortunate that our principal silk manufacturers were not represented; and the absence of the firm of Morris and Co. was a great loss to the reputation of the country. The British Fine Art Section was our chief glory, and the memory of it will dwell with all who saw it, to charm their lives for ever. The brilliant success of the Indian Court was peculiarly gratifying to old Indians, and the praise of it is equally due to Sir Philip Cunliffe Owen and Mr. C. Pardon Clarke, the learned and accomplished architect of the Court. India owes much to these International Exhibitions.

The International Exhibitions of 1851, 1857, and 1862, caused a great demand, which is every year increasing, for Indian carpets; those of 1868, and the aborted annual series held in 1871, 1872, and 1873 at South Kensington, widely diffused a taste for Indian jewelry in England; and at the Exhibition held last year in Paris, the pottery received from India particularly excited the admiration of the more cultivated visitors. In this paper I wish, through the agency provided by the Society of Arts, to draw popular attention to the interest awakened among the cognoscenti and curiosos at Paris in Indian pottery; and to the warning which I have elsewhere raised against the influences which are enfeebling and corrupting its artistic character, and which will only become aggravated by the commercial demand now sure to spring up for it, unless they are, from the first, intelligently resisted alike by its purchasers, importers, and manufacturers.

It is not, however, as in the case of Indian carpets and jewelry, exclusively through the medium of the International Exhibition that Indian pottery has been brought into the European market. For more than a year before it was seen at Paris it had been imported into London, in the regular course of trade, by Messrs. Howell and James, of Regent-street, and Messrs. Proctor and Co., of Oxford-street. The first consignments sent to Messrs. Howell and James were not of genuine native pottery, but the imitations of it manufactured by the Bombay School of Art; and as it is Messrs. Howell and James' chief object to introduce into this country representative and authentic examples of foreign ceramic art, their importations of Indian pottery have been suspended until they are able to establish direct communication with the native potters in Scinde and the Punjab Messrs. Proctor and Co.'s depôt for Indian art manufactures, in Oxford-street, was, I believe, opened about two years ago. In consequence of the depreciation in the value of silver about that time, it was determined by Messrs. Watson and Co., of Bombay, to "remit" in Indian manufactures to England; and thus Messrs. Proetor and Sons' business originated. They import every kind of Indian pottery for which they find a demand. But Mr. Watson, in Bombay, is giving the strictest personal attention to the preferential selection of genuine and typical native examples, and they have now ceased to import any of the Bombay School of Art manufacture that is merely imitative, and has not an original and distinctive character of its own.

The principal varieties of Indian pottery suitable for exportation are the red earthenware pottery of Travancore and Hyderabad, the red glazed pottery of Dinapoor, the black and silvern pottery of Azimghur and Surat, the painted pottery of Kotah, the gilt pottery of Amroha, the glazed and unglazed pierced pottery of Madura, and the glazed pottery of Scinde and the Punjab. In all these varieties of Indian fancy pottery an artistic effect is consciously sought to be produced; but only the pottery made at Azimghur, and in Scinde and the Punjab, and the Bombay School of Art pottery, were exhibited at Paris, and it is only of these examples that I can speak to-night.

The Azimghur pottery, like most of the art-work of the Benares district and eastward, is generally feeble and rickety in form, and insipid and meretricious in decoration, defects to which its fine black colour gives the greater prominence. The only tolerable example of it I have ever seen is the water-jug now exhibited, which attracts, and in a way pleases, because of the strangeness of look given to it by the pair of horn-like handles. The silvery ornamentation is done by etching the pattern, after baking, on the surface, and rubbing an amalgam of mercury and tin into it; thus producing the characteristic mawkish and forbidding effect, which the unsophisticated potter of Azimghur does not attempt to mystify by calling it by any of those advertising "cries," wherewith we are accustomed to make so much ado about nothing in our English art galleries and streets. If there is but little wool in the Azimghur potter's art, you are only asked to pay, literally, next to nothing for it, which is altogether better than paying an extortionate price for an artful cry, and often no wool at all. Very different is the glazed pottery of Scinde and the Punjab. The charms of this pottery are the simplicity of its shapes, the spontaneity, directness, and propriety of its ornamentation, and the beauty of its colouring. The first thing to be desired in pottery is beauty of form, that perfect symmetry and purity of form which is

"When unadorn'd, adorn'd the most."

When we get it, we desire nothing more for the satisfaction of the eye. But, for household use, pottery must generally be glazed, and neither glazing nor colouring need detract from its dignity or comeliness, while they often enhance the delicacy of surface required for the complete exposition of gracefulness of configuration. If any ornamentation is applied, it must be skilfully subordinated to the form to which it is superadded, so as not in any way to divert attention from it. Nothing can be in worst taste, nor, in an æsthetic sense, more wasteful, than to hide a lovely form under an excess of foreign ornament. It is really not less so to obscure it by producing the effect of floating birds and flowers about it, as is unintentionally done in so much English pottery, painted in perspective and with shadows; or by wilfully producing the illusion of forms dissimilar to the real form ornamented, as in Japanese pottery, in

which the attempt is often deliberately made to distract the eye by the most violent optical surprises and deceits. On the other hand, in the best Indian pottery, we always find the reverent subjection of colour and ornamentation to form, and it is in attaining this result that the Indian potter has shown the true artistic feeling and skill of all Indian art-manufacturers in his handiwork. The correlation of his forms, colours, and details of ornamentation is perfect, as if his work were rather a creation of nature—and this is recognised, even in the most homely objects, as the highest achievement of art. The great secret of his mastery is the almost intuitive habit of the native of India of representing natural objects in decoration in a strictly conventional manner; that is to say, symmetrically, and without shadow. In this way, the outline of the form ornamented is never broken. The decoration is kept in subordination to the form also by the monotonous repetition of the design applied to it, or by the simple alternation of two, or at the most three, designs. Also, never more than two or three colours are used, and, when three colours are used, as a rule, two of them are only lighter and darker tints of the same colour. It is thus that the Indian potter maintains inviolate the integrity of form and harmony of colouring, and the perfect unity of purpose, and homogeneity of effect of all his work. The mystery of his consummate work is a dead tradition now, he understands only the application of its processes, but not the less must it have been inspired in its origin by the subtlest interpretation of nature. The potters' art is of the highest antiquity in India, and the unglazed water-vessels, made in every Hindu village, are still thrown from the wheel in the same antique forms represented on the ancient Buddhistic sculptures and paintings. Some of this primitive pottery is identical in character with the vases found in the tombs of Etruria, dating from about B.C. 1000. I do not suggest any connexion between them, it is only interesting to find that pottery is still made all over India, for daily use, which is in reality older than the oldest remains we possess of ancient Greece and Rome. None of the fancy pottery made in India is equal in beauty of form to this primitive village pottery; and most of it is utterly insignificant and worthless. The only exception is the glazed pottery of Madura, and Scinde, and the Punjab. Madura pottery is Hindu in character, but that made in Scinde and the Punjab has been radically influenced by Saracenic art, and must be distinguished as Indian.

The glazed pottery of Scinde is made principally at Hala, and that of the Punjab at Lahore, Mooltan, Jang, Delhi, and elsewhere. It is said that the invasion and conquest of China by Chingiz Khan, in 1212, was the event that made known to the rest of Asia and Europe the art of glazing earthenware; but, in fact, the Saracens from the first used glazed tiles for covering walls, and roofs, and pavements, and of course with a view to decorative effect. The use of these tiles had come down to them in an unbroken tradition from the times of the Birs Nimrud, of "Temple of Seven Spheres" at Borsippa, of the temple of Sakkara in Egypt, and of the early trade between China and Egypt, and China and Oman, and the valley of the Tigris and Euphrates. Glazed tiles had, however, fallen into comparative disuse before the rise of the Saracens, and it was undoubtedly the conquests of Chingiz Khan, A.D.1206-27, which extended their general use throughout the nations of Islam. The glazed pottery of the Punjab and Scinde probably dates from this period, and as we shall presently see, was directly influenced by the traditions surving in Persia of the ancient civilizations of Nineveh and Babylon. It is found in the shape of dishes, plates, and water bottles, jars, bowls, and pots of all shapes and sizes, also of tiles, finials for the tops of domes, pierced windows, and other architectural accessories. In form, the bowls, and jars, and vases may be classified as egg-shaped, turband, melon, and onion-shaped, in the latter the point rising and widening out gracefully into the neck of the vase.

In the glazing and colouring two preparations are of essential importance, namely, *kanch*, literally glass, and *sikka*, oxides of lead. In the Punjab the two kinds of *kanch* used are distinguished as *Angrezi kanchi*, "English glaze," and *desi-kanchi*, "country glaze."

Angrezi kanchi is made of *sang-i-safed*, a white quartzose rock, 25 parts, *sajji*, or pure soda, 6 parts, *sohajatelia*, or pure borax, 3, and *nausadar*, or sal ammoniac, 1 part. Each ingredient is finely powdered and sifted, mixed with a little water, and made up into white balls of the size of an orange. These are red-heated, and after cooling again, ground down and sifted. Then the material is put into a furnace until it melts, when clean picked *shora kalmi*, or saltpetre, is stirred in. A foam appears on the surface, which is skimmed off and set aside for use. The *desi-kanchi* is similarly made, of quartzose rock and soda, or quartzose rock and borax, or siliceous sand and soda. A point is made of firing the furnace in which the *kanch* is melted with *kikar*, *karir*, or *Capparis* wood.

Four *sikka*, or oxides of lead, are known, namely, *sikka safed*, white oxide, the basis of most of the blues, greens, and greys used; *sikka zaid*, the basis of the yellows; *sikka sharbati*, litharge; and *sikka lal*, red oxide.

Sikka safed is made by reducing the lead with half its weight of tin; *sikka zaid* by reducing the lead with a quarter of its weight of tin; *sikka sharbati* by reducing with zinc instead of tin; and *sikka lal* in the same way oxidising the lead until red. The furnace is always heated in preparing these oxides with *jhand*, or *Prosopis* wood. The white glaze is made with one part of *kanch* and one part *sikka safed* (white oxide) well ground, sifted, and mixed, put into the *kanch* furnace, and stirred with a ladle. When melted, borax in the proportion of two *chittaks* (1 *chittak* = $\frac{1}{16}$ part of a *seer*) to the *seer* (a *seer* = 2 lbs.) is added. If the mixture blackens, a small quantity of *shora kalmi*, or saltpetre, is thrown in. When all is ready, the mixture is thrown into cold water, which splits it into splinters, which are collected and kept for use. All the blues are prepared by mixing either copper or manganese, or cobalt, in various proportions with the above white glaze. The glaze and colouring matter are ground together to an impalpable powder ready for application to the vessel.

The following are the blue colours used:—

1. *Firoza*, turquoise blue...	1 seer of glaze, and 1 chittak of *chhiltamba*, or calcined copper.
2. *Firozi-abi*, pale turquoise..	1 seer of glaze, and $\frac{1}{24}$ of calcined copper.
3. *Nila*, indigo blue	1 seer of glaze, and 4 chittaks of *rita*, or zaffre (cobalt).
4. *Asmani*, sky blue.......	1 seer of glaze, and $1\frac{1}{2}$ chittak of zaffre.
5. *Halka-abi*, pale sky blue..	1 seer of glaze, and 1 chittak of zaffre.
6. *Kasni*, pink or lilac.....	1 seer of glaze, and 1 chittak of *anjani*, or oxide of manganese.
7. *Sosni*, violet.......,....	1 seer of glaze, and $1\frac{1}{2}$ chittak of mixed manganese and zaffre.
8. *Uda*, purple or puce....	1 seer of glaze, and 2 chittaks of manganese.
9. *Khaki*, grey............	1 seer of glaze, and $1\frac{1}{2}$ mixed manganese and zaffre.

The *rita* or zaffre is the black oxide of cobalt found all over Central and Southern India, which has been roasted and powdered, mixed with a little powdered flint. Another mode of preparing the *nila*, or indigo blue glaze, for use by itself, is to take:—

Powdered flint.....................	4 parts.
Borax	24 ,,
Red oxide of lead.................	12 ,,
White quartzose rock.............	7 ,,
Soda	5 ,,
Zinc.............................	5 ,,
Zaffre...........................	5 ,,

All are burnt together in the *kanch* furnace as before described.

The yellow glaze used as the basis of the greens is made of *sikka zard*, white oxide 1 seer, and *sang safed*, a white quartzose rock, or millstone, or powdered flint, 4 chittaks, to which, when fused, 4 chittaks of borax are added.

The green colours produced are:—

1. *Zamrudi*, deep green..	1 seer of glaze, and 3 chittaks of *chhil tamba*, or calcined copper.
2. *Sabz*, full green	1 seer of glaze, and 1 chittak of copper.
3. *Pistaki*, or Pistachio (bright) green	1 seer of glaze, and $1\frac{1}{2}$ chittak of copper.
4. *Dhani*, or Paddy (young shoots of rice), green..	1 seer of glaze, and $\frac{1}{128}$ chittak of copper.

Another green is produced by burning one seer of copper filings with *nimak shor*, or sulphate of soda.

The colours, when powdered, are painted on with gum, or gluten. The vessel to receive it is first carefully smoothed over and cleaned, and, as the pottery clay is red when burnt, painted all over with a soapy, whitish engobe—prepared with white clay and borax, and *Acacia* and *Conocarpus* gums — called *kharya mutti*. The powdered colours are ground with a mixture of *nishasta*, or gluten and water, called *mawa*, until the proper consistence is obtained, when they are painted on with a brush. The vessels are then carefully dried, and baked in a furnace heated with *ber*, or *Zizyphus*, or sometimes *Capparis* wood. The ornamental designs are painted on off-hand, or a pattern is pricked out on paper, which is laid on the vessel and dusted with the powdered colour along the prickings, thus giving a dotted outline of the design, which enables the potter to paint it in with all the greater freedom and dash. It is the plucky drawing, and impulsive, free-handed painting of this pottery which are among its attractions. The rapidity and accuracy with which the whole thing is done is a constant temptation to the inexperienced beholder to try his hand at it himself. You feel the same temptation in overlooking any native artificer at his work. It appears to be so easy, and his tools are so simple, that you think you could do all he is doing quite as well yourself. You sit down and try. You fail, but will not be beaten, and practise at it for days with all your English energy, and then at last comprehend that the patient Hindoo handicraftsman's dexterity is a second nature, developed from father to son, working for generations at the same processes and manipulations.

The Indian potter's wheel is of the simplest and rudest kind. It is a horizontal fly-wheel, two or three feet in diameter, loaded heavily with clay along the rim, and put in motion by the hand; and once set spinning, it revolves for five or seven minutes with a perfectly steady and true motion. The clay to be moulded is heaped on the centre of the wheel, and the potter squats down on the ground before it. A few vigorous turns, and away spins the wheel round and round, and still and silent as a "sleeping" top, while at once the shapeless heap of clay begins to grow under the potter's hand into all sorts of faultless forms of archaic fictile art, which are carried off to be dried and baked as fast as they are thrown from the wheel. There is an immense demand for these water-jars, cooking-pots, and earthen frying-pans and dishes. The Hindoos have a religious prejudice against using an earthen vessel twice, and generally it is broken after the first pollution, and hence the demand for common earthenware in all Hindoo familes. There is an immense demand also for painted clay idols, and thus the potter, in virtue of his calling, is an hereditary officer in every Indian village. In the Deccan, the potter's field is just outside the village. Near the wheel is a a heap of clay, and before it rise two or three stacks of pots and pans, while the verandah of his hut is filled with the smaller wares and painted images of the gods and epic heroes. He has to supply the entire village community with pitchers and cooking pans, and jars for storing grain, and spices, and salt, and to furnish travellers with any of such vessels as they may want. Also, when the new corn begins to sprout, he has to take a jug and water vessel to each field for the use of those engaged in watching the crop. But he is allowed to make bricks and tiles also, and for these he is paid, exclusively of his fees, which amount to between £4 and £5 a year. Altogether he earns between £10 and £12 a year. He enjoys, besides, the dignity of certain ceremonial and honorific offices. He bangs the big drum, and chants the hymns in honour of *Jamee*, an incarnation of the great goddess *Bhowanee*, at marriages; and at the *dowra*, or village harvest home festivals, he prepares the *burbut*, or mutton stew. He is, in truth, one of the most useful and respected members of the community, and in the happy theocratic

organisation of Hindoo village life there is no man happier than the hereditary potter, or *Koombar*.

We cannot overlook this serenity and dignity of their lives if we would rightly understand the Indian handicraftsman's work. He knows nothing of the desperate struggle for existence which oppresses the life and crushes the very soul out of the English working man. He has his assured place, inherited from father to son for a hundred generations in the national church and state organisation; while nature provides him with everything to his hand, but the little food and less clothing he needs, and the simple tools of the trade. The English working man must provide for house rent, coals, furniture, warm clothing, animal food, and spirits, and for the education of his children, before he can give a mind free from family anxieties to his work. But the sun is the Indian workman's landlord, and coal merchant, upholsterer, tailor, publican, and butcher; the co-operative store from which he gets almost everything he wants and free of all cost in coin. This at once relieves him from an incalculable dead weight of cares, and enables him to give to his work, which is also a religious function, that contentment of mind and leisure, and pride and pleasure in it for its own sake, which are essential to all artistic excellence. The cause of all of his comfort, his hereditary skill, and of the theocratic constitution under which his marvellous craftsmanship has been perfected, is the system of landed tenure which has prevailed in India, and stereotyped the civilisation of the country from the time of the Code Menu. The Indian *ryotwaree* tenure, or system of peasant proprietorship, is first and most simply described in the Bible, in the xlvii. chapter of Genesis. In the seven years of plenty in Egypt Joseph gathered the fifth part of all the grain grown in those plenteous years, and laid it up in the cities; and when the famine came, in the first year he gathered into Pharoah's treasury all the money in the land of Egypt and in the land of Canaan for the corn which he sold to the starving people, and when their money failed, all their cattle; and in the second year, when their money was spent, and their herds gone, he took from them all their lands, and even bought themselves into slavery, and fed them with bread for their lands and their bodies for that year. Thus the whole land of Egypt became the property of King Pharoah, and all the gold and silver of the people beside, and when only their bodies were left before him, they were sold in bondage to the king. And having swept away the ancient freehold proprietors of Egypt, Joseph made a new distribution of the land among the husbandmen, requiring them to pay in return one-fifth part of their crops as rent or tax into the king's treasury. This is the regular *ryotwaree* tenure with a very moderate assessment, for whereas in most Asiatic countries the assessment generally amounts to one-half the crop, Joseph only exacted one-fifth; and it is not surprising, therefore, to find that the children of Israel who dwelt in the Land of Goshen, and had in possession the best of the land therein, prospered and multiplied exceedingly. The temple endowments, the lands of the priests, Joseph did not touch. This is a peculiarly interesting chapter to Anglo-Indians. In the end, only the legends of human pathos survive in history, and Joseph is popularly known chiefly in connection with the story of his evil treatment by his brethren, and his touching requital of tenfold goodness into their bosoms. He was really the astute and far-sighted author of one of the greatest and most successful agrarian revolutions on record, beside which the revenue reforms of Todar Mal, under Akbar, and the "Cornwallis (Permanent) Settlement" of 1793, and the revenue survey of the North-West Provinces, by Robert Bird, in 1824, shrink into insignificance. The system of peasant proprietorship may possibly contribute indirectly to retard the advancement of a country, even where it does not conduce directly to the petrifaction of its civilisation, as in India. Under it the Hindoo ryot has become so strongly attached by the most sacred and deeply rooted ties to the soil, that, rather than relinquish his hold on it, he will burden himself and his heirs with debt for generations; and gradually, under the Hindoo practice of inheritance, the holdings become so minutely subdivided, and overburdened by mortgages, that extended cultivation and high farming are made almost impossible. Notwithstanding the superior education of the Scotch peasantry, and the livelong example of the benefits of high farming all around them, it is only in the last few years that the "portioners" of the Lothians and the Merse have learned to combine together to work their "common lands" by the steam plough. At this rate the village communities of the Deccan may be expected to postpone the scientific cultivation of the limitless arable soil of India to the Greek Kalends. It is a notable fact that while machinery should have been so readily applied in India to the production of textile and other manufactures, in which its use is injurious, its introduction in agricultural operations, in which it would so incalculably benefit the people, has been found impossible. It is quite impossible under the land system of the country at present. I remember a steam plough being introduced with great *éclat* into the Bombay Presidency. It was led in procession into the field wreathed in roses, and all of us who went to see it were wreathed with roses, and sprinkled with *attar*. But it was found impossible, utterly, to make any use of it. It was introduced into a fixed, crystallised sacro-economic system in which it had no place, unless as a new divinity, and a new divinity and an idol it was made. It was put away into the village temple, and there, after a time, its great steel share was bedaubed red, and worshipped as a god. As a mere question of accounts, there can be no doubt of the solvency of India, but owing to the restricted and imperfect cultivation of its soil, it is incapable of supporting the great cost of good government in modern times with the elasticity and buoyancy which would at once result from the proper development of its really inexhaustible agricultural resources. The country grows rich too slowly, and the demands of a scientific government increase on it too rapidly, and the reason of it undoubtedly consists in the Indian form of peasant proprietorship. Then again, under this system, as it has been elaborated in India, there is a great loss of personal and national energy. The whole community is provided for; every man in it has his ordered place and provision. There is no stimulus to individual exertion, and the mass of the people are only too well contented to go on for ever in the same old-

fashioned conservative ways as their fathers from time immemorial before them. In England, the law of primogeniture, while so hard on younger sons, by throwing them on their own resources, to provide for themselves in the free professions, in commerce, and the colonies, has had the most beneficial influence on the energy of the race, and the growth of the wealth and political liberties and power of the country during the last two hundred years. Primogeniture, also, has given England a highly cultivated and powerful governing class; and every parish in the country has its "King in Israel." All this may be conceded, and even the desirability, in the last far-off result, of a change in the old order of village life in India, to something newer and more modern. It is only to be hoped that the inevitable revolution will be left alone to the benign action of time, and of the economic causes by which the country is being gradually affected through its connection with England. Perhaps the first forward step in the new departure will be taken by the much abused village *soucar*, or banker. The *ryot*, the pet lamb fatted up for the revenue commissioners' knife, is protected by the paternal Government against all others having a claim on his fleece. The Government has only mercilessly to leave him alone with his secular enemy — the *soucar*, and the village fields would probably soon pass from the poor peasant proprietor to the rich banker, and, held in fee simple, might at last be cultivated with the fullest advantage to the landlord and the State. Of course, it would be in the programme that the communal villages disappeared. The *ryotwaree* tenure is very like freehold, but as it, in benevolence to the ryot, allows him to retain his lands as long as he pays the assessment on them, although he may never cultivate them, it so far restricts the transfer and proper cultivation of the land. Also, among an ignorant peasant population, the periodical revision of the assessment, paternally devised in the ryot's own interest, only serves to make him uncertain of the fixity of his tenure, and thus to restrict the improvement of his property. Even the annual settlement, which is not made to re-assess the land, but to determine the amount of remission to be made for bad crops, and fields not cultivated, leads to the same result, and to unsettlement of mind, and ill-will toward the Government. The ryot schemes through all the year, even against his own best interest, to swell the remissions as much as possible, and is never quite satisfied with the amount actually allowed him.

The whole of this indictment against the *ryotwaree* tenure, prevailing over the greater part of India, may be conceded; but we owe to it all the primitive arts of India, and when it becomes disorganised and perishes, they too will sink and pass away for ever. It created the conditions of society, so picturesque in its outward aspects, so simple and fascinating in its inner life, in which the arts of India originated, and on the permanence of which their preservation depends. For leagues and leagues round the old Mahratta cities of Poona and Sattara stretch fields of corn, and pulse and oil grains, and deep dyeing flowers, the lively verdure of the rice fields following the courses of the more irriguous mullahs, like a green thread wrought in gold; and rich orchards, and high groves of mango mark the sites of the villages hidden in their shade. Glad with the dawn the men come forth to their work, and glad in their work they stand all through the noontide, singing at the well, or shouting as they reap and plough; and as the stillness and the dew of eve fall upon the land like the blessing and the peace of God, the merry-hearted men gather with their cattle in Indian file, in long winding lines, to their villages again; slowly, over all the wide champaign, the black lines disappear into the lengthening shadows of the mango trees, and the day is closed in night. Thus day follows day, and all the year is crowned with gladness. It is in the contemplation of such scenes as these that the Englishman in India drinks deep of the bliss of knowing others blest. Is not the existence of the Indian ryot under the "English peace," in fact, the ideal of the poet and poetical economist? Does it not realise that life of contentment in moderation which is the favourite theme of Horace? Here is no

"Indigent starveling among mighty heaps."*

The accumulation of immoderate wealth is impossible,

"Yet far aloof is irksome poverty."

And are not these the conditions under which archaic art and song have everywhere sprung?— and which are everywhere found essential to the preservation of their pristine purity? To the Indian land and village system we obviously owe the hereditary cunning of the Hindu handicraftsman. It has created for him simple plenty, and a scheme of democratic life, in which all are coordinate parts of one undivided and indivisible whole, the provision and respect due to every man in it being enforced under the highest religious sanctions, and every calling perpetuated from father and son by those cardinal obligations on which the whole hierarchy of Hinduism hinges. India has undergone more religious and political changes than any other country in the world, but the village communities remain in full municipal vigour all over the Peninsula. Scythian, Greek, and Saracen, Afghan, Mongol, and Mahratta have come down from its mountains, and Portuguese, Dutch, French, and English up out of its seas, and set up their successive dominations in the land, but the theocratic rural villages have remained as little affected by their coming and going as a rock by the rising and falling of the tide; and there, at his daily work, has sat the hereditary village potter amid all these shocks and changes, steadfast and unchangeable for 3,000 years, Macedonian, Mongol, and Mahratta, and Portuguese, Dutch, and French, no more to him than the broken potsherds round his wheel. Could our deeply erring spendthrift School Boards improve on him?

The art of glazing pottery in Scinde and the Punjab is probably not older than the time of Chingiz Khan. In all the imperial Mogul cities of India where it is practised, especially in Lahore and Delhi, the tradition is that it was introduced from China, through Persia, by the Mongols, through the influence of Tamerlane's Chinese wife; and it is stated by independent European authorities

* I quote Horace in Mr. Thornton's translation, the attraction of which, for those who have ceased to be at home in classical Latin, lies in the felicity with which, while literal, it preserves the grace and harmony of the original.

that the commencement of ornamenting the walls of mosques with coloured tiles in India is contemporary with the Mongol conquest of Persia. But in Persia the ancient art of glazing earthenware had come down in an almost unbroken tradition from the period of the greatness of Chaldea and Assyria, and the name *kasi*, by which the art is known in Persia and India, is the same Semitic word, *kas*, glass, by which it is known in Arabic and Hebrew, and carries us back direct to the manufacture of glass and enamels, for which "great Zidon" was already famous 1,500 years before Christ. The pillar of emerald in the temple of Melcarth, at Tyre, which Herodotus describes as shining brightly in the night, can, observes Kenrick, hardly have been anything else than a hollow cylinder of green glass, in which, as at Gades, a lamp burnt perpetually. The designs used for the decoration of this glazed pottery in Scinde and the Punjab also go to prove how much it has been influenced by Persian examples, and the Persian tradition of the ancient art of Nineveh and Babylon. The "Knop and Flower" pattern, the origin of which I have discussed at length in the "Handbook to the Indian Court at Paris," and which we all know in Greek art as the "Honeysuckle and Palmette" pattern, appears in infinite variations on everything. The specimens exhibited to you illustrate this.

The Bombay School of Art pottery we owe chiefly to the exertions of Mr. Terry, the superintendent of the school. He has introduced potters from Scinde, but as yet I have never seen any pottery from the school in imitation of that made in Scinde and the Punjab, which is quite satisfactory; while that produced by the students of the school, who have set up as potters on their own account in Bombay, in imitation of the Scinde pottery, is simply detestable. The failure is particularly conspicuous in the blue, and blue and white ware, of which I have never seen a good specimen from the school or its pupils. Whatever of it comes from Hala, Mooltan, or Lahore is always superlatively fine — both in colour and design. One of the worst faults of the Bombay School of Art imitation pottery is in the application of the Scinde and Punjab decorative designs to vessels of Chinese and European forms. Latterly, however, Mr. Terry has been himself designing his school pottery, to which he is at last succeeding in giving a specific character of its own. In some of it the designs are adapted from the Ajunta cave paintings, and it is highly interesting to see Hindoo mythological subjects drawn in the native manner under the direction of a practised English draughtsman; but the very best of the Terry-ware are the specimens in which the designs are wholly of Mr. Terry's own inspiration.

I have gone so much into the Indian potter's surroundings and antecedents because we can only proceed profitably by a chronological and historical reduction, of the origin of an art. I need not say how much an intelligent study of the influences under which the arts of India have been produced and are sustained will help to a fuller understanding of the origin and development of Indo-European art generally. The languages and mythologies of the Indo-European nations were never recognised to be one, until the key to their unity was found in the sacred language and religion of the Hindoos, and the scientific investigation of Indian art will not fail to lead to profitable, and, perhaps, ever surprising results. But, personally, I view the matter from totally another point. Nothing conduces more than such studies, and the conclusions to which we now see they almost invariably lead, to free men from all jealousies of race, and international prejudices, and all narrow provincial and insular ideas. Europe and Asia are one continent, and the English and Hindoos one family, united by a common origin, language, and history; and the more widely this is seen and felt, the more will they become united by a common sympathy in all the higher, nobler aims of life. To promote, so far as in me lies, a mutual sympathy between English people and the people of India, is my first purpose, and I trust it will be your first interest—if I have succeeded in interesting you at all—in this paper.

DISCUSSION.

Mr. Andrew Cassels said Dr. Birdwood evidently belonged to the class of idealists, for, in connexion with Indian pottery, he had taken them back to the days of Joseph and the land tenure of Egypt. He admired the paper exceedingly; but he was afraid that art in India was very much degenerating. The Cashmere shawls of to-day were not to be compared with those produced 50 years ago, and this he attributed to the bad designs sent out from France. There was also a great falling off in the silver work which came from India, and this he traced to the fatal influence coming from Birmingham. All the old original shapes were disappearing, and in Cutch and elsewhere they were adopting in their place designs which found more favour in England. The carpets of India were not the same as they used to be, and he feared the commonplace designs produced in the gaols were producing a bad effect on the manufacture generally. In like manner the imitation of modern art was gradually undermining and destroying the more pure and beautiful native art of India. Nothing could be more beautiful than some of the native colours, and no nation in the world better understood their combination. He, for one, deeply regretted what he considered the degradation of Indian art.

Mr. Kipling (of the Government School of Art at Lahore) agreed with the last speaker that there was an undoubted decadence in Indian art all along the line. He could not say that it was the breaking up of the village system that had brought this about, for he thought they really had to blame the march of civilisation. The steam-engine, with all the material benefits which it had brought, was bringing to the natives of India many serious disadvantages. As regards these beautiful examples of archaic art, their very excellence, their simplicity and beauty, were disturbed by the introduction of modern ideas. If you could establish a kind of artistic Custom-house at Bombay and other ports, which would stop every article from Birmingham, or Manchester, or of Parisian or Prussian manufacture, no doubt you could preserve the people from artistic deterioration, but otherwise he feared not. It was to be hoped, however, that when the public saw a good thing, whether it came from the Bombay School of Art or elsewhere, they would buy it at once, and not grudge the price they gave for it, because they might be sure that the law of supply and demand would not be abrogated, and that it would produce some good effect. At present, all the new architecture of India was designed by the Public Works Department, which included a

most excellent and admirable body of engineers, who naturally worked on English traditions, and did not see the beauty of the indigenous architecture of the country.

Mr. H. Doulton said that Dr. Birdwood's description of India made him think it must be the very paradise of potters, and it was rather tempting to a potter to migrate there. He had been struck with two things in particular in the paper. The first was, that all this beautiful work was hand-work, and not produced by machinery—for machinery seemed to be the death of art. He did not want to say anything against it, but it ought to do the drudging work of the world, for when it had to do with art it destroyed it. Then, secondly, the paper taught them that they should not imitate, because, when manufacturers began to imitate, they ceased to be artistic. There were some very beautiful specimens on the table, which he thought might do a great deal of good in stimulating the English manufacturers. If these forms were studied and considered, they might do a great deal of service, especially if studied in connection with the paper which had been read.

Mr. Vincent Robinson said he was not technically acquainted with this subject, but he certainly felt that Dr. Birdwood had done great justice to it, and it was one of deep interest to anyone who had any enthusiasm for Indian art It seemed to him that machinery was doing a great deal of mischief, and that they should, if possible, encourage hand manufactures, and discourage those that were mere imitations and machine work. Those copies from the designs of the Ajunta caves were exceedingly tame, and were in every way to be discouraged, because they were not fitted for the small surfaces which these vessels necessarily offered for decoration. An elephant seemed to him to be quite an inappropriate object for the decoration of such small surfaces. The conventional form was much better than grotesque forms, imitated in the tame manner which nearly all these things from the Indian School of Art showed. If it were possible that these grand patterns and this bold colouring of the jars shown by Dr. Birdwood could be encouraged, rather than the small tame patterns which they were now turning out from the school at Bombay, it would be a great advantage.

Mr. Rogers remarked that a great deal had been said at the close of the paper with regard to the form of these native articles, but he had noticed one important omission, viz., nothing had been said as to the clay of which they were manufactured. This was a very important question, and anyone who had studied Indian pottery at all must be aware of what very imperfect material these pots were made. He could answer for Mr. Terry that he was most enthusiastic, especially in this point, and paid great and particular attention to the material of which his pottery was made. He had been the means of bringing to his notice substances from different parts of the Bombay Presidency, to which he had paid great attention, and if any competent potter were to examine the products of the Bombay school, he would find the material far better than that produced in different parts of India. He had nothing to say against the remarks of the lecturer with reference to the glaze and general conception of form, but anybody who would take these forms, made by native potters, and examine them critically, would find that not a single one was perpendicular.

Dr. Birdwood said that was a merit.

Mr. Rogers said he could not say that himself, but he would leave the audience to judge whether or not a pot should be perpendicular. At any rate, he believed that the things made in the School of Art under Mr. Terry's superintendence would be straight, and if they were not so in the first instance, he was sure that they would be in the future—that might be one advantage in the introduction of machinery. He hoped that all credit would be given to Mr. Terry's School of Art, which he thought was the only place where attention was given to improve the native notions of art. Mr. Terry had no idea of destroying native art, but of improving it, and he was perfectly certain that in time he would succeed, if people would only make due allowance for all the difficulties he had to contend with, considering which it was wonderful that he had done so much as he had.

Mr. Griffiths thought Dr. Birdwood had been rather hard on Mr. Terry, considering the difficulties he had to contend against, and especially as he paid for this pottery out of his own pocket, the Government giving no aid beyond finding accommodation. As for the statement that they copied Doulton ware, he could vouch for it that they never saw any of it in Bombay.

Dr. Birdwood said they sent for samples to copy. He had seen the correspondence.

Mr. Griffiths believed this was a mistake. Again, stencilling was a thing never resorted to. Again, he understood Dr. Birdwood to say that English draughtsmen drew the designs, but that was not so—they were all done by Indian workmen; and the manufacture was under the superintendence of the best man Mr. Terry could procure from Scinde. Mr. Terry designed none of the patterns himself; the students themselves designed them. The first batch which Mr. Terry sent to Messrs. Howell and James they admired very much, as regards colour and so on, but they could not sell them, because there was no demand. He thought Mr. Terry had been rather hardly dealt with.

Dr. Birdwood protested against such an idea, as he had the greatest possible sympathy with Mr. Terry's efforts.

Mr. Doulton said one great characteristic of this pottery was that it was all thrown on the wheel, and that accounted for it not being always upright. But that was its charm. The extreme uniformity obtained by moulding was detrimental to true art. The art of throwing he considered the most beautiful of all; by its means, with a revolving disc, the workman's hand with the aid of a little water evolved the most beautiful forms out of a lump of clay; but it took a long time to learn. Of late years the tendency had been to mould things, and it was easy enough with a templet to make a beautiful shape, which would stand upright, but it had no life in it. He had taken great interest in the encouragement of this art of throwing, and he was glad to say that the Turners' Company had offered prizes, most of which the Lambeth people had won. He hoped on future occasions the Staffordshire potters would take their share, and he felt that if beautiful interesting pottery was to be made, this art of throwing must be encouraged. A good potter was constantly finding some new form if he had any taste at all; and it was surprising what could be done with the manipulative dexterity acquired by years of practice.

Mr. Sparkes (Master of the South Kensington Art School) was anxious to reconcile the apparently contradictory statements of Dr. Birdwood and Mr. Griffiths. He remembered the first lot of pottery which came from the Bombay School of Art, to Messrs. Howell and James; the pots were made of very fragile material, and were nearly all broken; but from those which remained, and the pieces of the others which could be put together, the forms were found to be singularly hideous, and they would not sell at all. They, therefore, asked him if he would give them some tracings or outlines of forms which had been found useful at Lambeth, and he believed some of those tracings were sent to Mr. Terry, with what result he did not know. But, at any rate, the letters Dr. Birdwood referred to were those in connection with the traced outlines of forms which were found to be successful in England. He was not aware that any Doulton ware had ever been sent

of India, at any rate he could see no trace of its influence on the productious of the Bombay School of Art. He knew nothing of the school, but he could not help thinking that Dr. Birdwood had been a little hard upon it. His view of the case was that Mr. Terry—and whoever was to be thanked for that effort had exactly the same instinct as he had himself—was anxious to graft on to the native handicraft a new development, and perhaps to introduce a new manufacture altogether in the district, and he looked about for materials close at hand which his native artisans could work into pottery, whilst he very properly sent to Scinde for a technical workman to direct the operations. The students then went to the Ajunta caves, copied the decorations, and adapted them to the pottery, and that seemed perfectly legitimate. Mr. Terry, at present, he took it, was merely feeling his way; but it must come to a good end, if he could graft a new manufacture on to the native tact and taste. The forms he had hitherto seen had been archaic and rude to a degree, and, probably, the instincts, to which we owed many bits of Indian pottery, might be ruder ones, in this sense—that the natives might have the sense only of one form, and it might be impossible for them to perceive others which, to educated eyes, were more graceful. The value of this Indian ware had hardly been sufficiently dwelt upon. No one had been more successful in imitating some of these beautiful combinations of blue and turquoise than Deck, of Paris; but those beautiful vases of Deck's, which were enormously expensive, were harder, and, to his taste, less artistic than some of these rougher articles from India. The difference was that Deck's were more or less copied, and these were the pure products of the instincts of an artistic people. The influence of these things had been very great on English manufactures. No branch of the art *faïence* of Messrs. Doulton had been more admired than the Persian Section, which was in fact based on these combinations, but they were unable to reproduce the same colours, and they were obliged to substitute for them what came nearest. Each material employed, the fire in which it was burned, the colours and the glaze which covered them, were all factors in the result, and if any one were changed the result was different. It was therefore perfectly fallacious to give recipes for colours or glaze, or anything else. The work must develop itself, and he felt sure that the Bombay School would develop; and there was ample room in England and on the Continent to absorb all that could be made both here and in India.

Dr. Birdwood, in concluding the discussion, said that Mr. Rogers had spotted a large omission in his lecture, but it had been deliberate. The clays constituted a subject by themselves, which could hardly be treated profitably in his paper. His chief object was to interest the world of art in England in Indian pottery; he wanted to advertise and increase a new Indian export. He regretted that any awkwardness of expression on his part, either in the "Handbook on the Indian Court," or in the present lecture, should have led anyone to suppose that he was unjust to Mr. Terry. He read the passages complained of, and asked if they really bore a meaning adverse to his (Mr. Terry's) labours in Bombay. No one more appreciated Mr. Terry's quick sympathy with native art, and enthusiastic efforts to introduce the manufacture of glazed pottery into Bombay. He only condemned the imitated ware, or what of it he had ever seen. He felt, however, that the School of Art imitated ware was discredited by the work of its pupils, who had set up as potters on their own account. It was true that they had a Scinde potter at the school, but he seemed to have lost his cunning in Bombay, if the imitation Scindeian pots sent to this country were of his handiwork. He left it to the audience to judge between the pots and pans on the table from Scinde and those from the Bombay School of Art. The genuine Terry ware—he meant the things of Mr. Terry's own designing, and having an original and specific character of their own—he highly prized. No one bought more of it than he did, and purposely to give to people who were likely to stimulate a demand for it. But a bad pot, whether in shape, quality of surface, colour, or design, he would always damn, and eternally if he could. The truth was, as the history of every art showed, perfection could only be reached through suffering, and he was sure that Mr. Terry himself must have occasionally suffered infinitely in the contemplation of some of his inevitable failures. He was nobly essaying to rival an art of three thousand years growth in India, and no one more sincerely and warmly wished him success than himself.

The Chairman said he felt great sympathy for the School of Art at Bombay, which would probably consider itself very fortunate if, like Mr. Sparkes, who had been the great author of the Doulton ware, they had such liberal patrons as the Messrs. Doultons, to aid in the development of this artistic manufacture, which had made their name and the ware, and the country which produced it famous throughout the world. These gentlemen at Bombay had not yet found any Doultons, but if they could get any of their own merchant princes to come forward in like manner, the school might receive that encouragement which, he was sorry to say, it did not receive from the Indian Government. It was no business of his, as a Government official, to say anything about that, but he could not help feeling that this effort of Mr. Terry's deserved all the encouragement which the public could give it by creating a demand for it productions. The success of the Indian Section at the Paris Exhibition was due first to Mr. Purdon Clarke, and they had also to thank Dr. Birdwood, who was their adviser in everything. The French people were delighted with the pottery, and if they had had the means to import sufficient to fill the whole vestibule with Indian pottery, he believed it would have been all disposed of. He felt certain that the Bombay School of Art had not only gained a great deal by the discussion, but it had gained a good deal of credit in France, and he hoped Mr. Kipling and Mr. Griffiths would take back with them all the encouragement possible. He knew nothing technically about pottery, and could not enter into the discussion, but he would conclude by proposing a vote of thanks to Dr. Birdwood for his interesting paper.

The vote of thanks being carried unanimously the meeting adjourned.

The paper was illustrated by specimens lent by the India and South Kensington Museums, and by Messrs. Procter and Co., Oxford-street; also by specimens, the personal property of Dr. Birdwood, and other gentlemen present.

MISCELLANEOUS.

NEW PATENT BILL.

On the 25th inst., there was printed a Bill—the Patents for Inventions Bill (No. 2)—introduced by the Attorney-General, "to consolidate, with amendments, the Acts relating to letters patent for inventions." The Bill is prefaced by a memorandum, showing the principal amendments in the law which will be effected by the Bill. They are thus briefly indicated:—

"Additional unpaid Commissioners (cl. 5). Extension of provisional protection to 12 months (cl. 7). Publication of complete specification three months at least before end of provisional protection (cls. 8, 9). Only opposed cases referred to law officer (cl. 10). Appeal by petition to Lord Chancellor against law officer's report

(cl. 13). Any person may oppose sealing (cl. 14). Extension of term to 21 years (cl. 16), power of prolongation by Judicial Committee being abolished by repeal by Bill. Relief on accident, mistake, or inadvertence preventing payment in due time of periodical stamp duty (cl. 16). Large power of amendment before and after sealing (cl. 17). Improved procedure as to disclaimers and alterations (cl. 17). Binding of Crown, with power for contractors to use, on terms (cl. 18). Compulsory use or licensing (cl. 19). Abolition of *scire facias* (cl. 23). Abolition of communications from abroad, and regulation of patents for imported inventions (cl. 24). Power for law officer to take evidence on oath (cl. 30). Power for Lord Chancellor to appoint Judge of High Court to hear patent petitions (cl. 33). Proper particulars of objections or of breaches required in all cases (cl. 34). Experts (cl. 36). Large powers to regulate procedure by general orders (cl. 39), and office practice by general rules of Commissioners (cl. 44). Patent Museum provided for (cl. 44*f*). Lower stamps (cl. 47); first cost of patent will usually be £17 10s., or, if no amendment before sealing, £12 10s., instead of £25 (2nd schedule)."

Some "Observations on Clauses" follow:—"Cl. 2. Commencement of Act is to date from end of 1879; but under clauses 5, 39, 44, additional Commissioners may be appointed, and general orders and general rules be made, on passing of Act, before commencement.

"Cl. 15 (5). Patents will not extend to the colonies; the colonies now have their own systems.

"Cl. 16 (2). The twelfth year is taken, instead of the fourteenth, for payment of the last stamp fee, in order that the public may have long notice of the patentee's intention to renew beyond the 14 years.

"Cl. 16 (3). There have been many cases of loss of patents from the causes here mentioned. There have been several instances of private Acts of Parliament obtained to restore patents thus lost (with proper savings). When indulgence is granted under this provision, the patentee will have to pay an additional fee of £5 or £10 (2nd schedule). It will no longer be necessary for the patentee, on renewing, to produce the letters patent themselves or a duplicate thereof; the stamp will be put on the certificate of renewal, which will be issued at the Commissioners' office.

"Cl. 17 (1). At present, reasons are given for disclaimer only. Amendment by way of supplement is new, and will probably get rid of the considerable proportion of separate patents now taken out for small improvements which are invented in the course of the use of the patented invention.

"Cl. 19. The object is to prevent patentees from monopolising privileges while not using them for the benefit of the community."

Schedule 1 contains a list of seven existing Acts which will be repealed under the Bill. All, excepting 5 and 6 William IV., chap. 83, are statutes of the present reign.

FORTHCOMING EXHIBITION AT THE PALAIS DE L'INDUSTRIE, PARIS.

The Exposition of 1878 had not closed before the announcement appeared of another exhibition to be held during the latter part of the present year. While the classification, which will be given further on, embraces a wide field, the object is to a certain extent different, as processes will be represented rather than production, the latter, however, being admitted as illustrations of the former. As the sciences are the sources of practical discovery, it is argued by the promoters that the present exhibition of scientific applications, especially the most recent, to the various branches of industry will have the effect of inciting to study, investigation and invention, and form "an important corollary of the Universal Exhibition of 1878." It has also been thought that, as during the continued depression of trade, time has been afforded for inquiry into the interchange of products, now is an opportune moment for an Exhibition of improved systems of manufacture.

The president of the superior committee is M. Cocherie, Under Secretary of State at the Ministry of Finance; the Secretary-General, M. de la Bruyère, Administrateur de la Caisse d'Epargne de Paris; and the director, M. P. Nicole, Administrateur Général de l'Union Syndicate de Paris, who organised the Hâvre Exhibition in 1867, and the Exposition Maritime et Fluviale in 1875.

A special feature of the exhibition will be the reproduction of a glacier, 30 feet high, with a grotto inside, in which will be shown the various geological strata with the fossils belonging to each. There will also be a reproduction of a prehistoric habitation, the hut of savages at the present day, and a model dwelling with the most approved arrangements as regards sanitary science and comfort. These reproductions, with a relief map of Europe during the tertiary period, a dioramic view of the site of Paris before the appearance of man upon the earth, and also during the cave period, will be contributed by the management of the exhibition, and from Group X. of the classification.

Group I. relates to prehistoric knowledge, anthropology, and education.—Class 1 embraces ethnographical collections, illustrating the life of primitive man and modern savages, with specimens of prehistoric habitations, while, by way of contrast, Class 2 will contain specimens of various industries at the present day, showing the life of civilised beings in different countries. Class 3 is devoted to ecclesiastical art, and class 4 to education and instruction, comprising schools for the deaf and dumb and blind; trade—commercial and agricultural—schools; the higher education, and apparatus and methods of instruction.

Group II.—*Applied Physics.*—Class 5 includes all the more recent applications of electricity, and the electric light; Class 6, the electric telegraph, with the various transmitting and receiving instruments, and the working of the telephone on telegraphic wires; Class 7, processes and specimens of electro-metallurgy; Class 8, optical instruments for both science and industry; Class 9, photography, including its new applications, and other methods of utilising light; Class 10 (the production of heat and cold) embraces the utilisation of solar and terrestrial heat, machines for making artificial ice, and for the liquefaction of gases, as well as instruments for measuring degrees of heat and cold; Class 11 (warming, lighting, and ventilation) includes fire places, stoves, apparatus for the use of mineral oil for domestic and industrial purposes, artificial gas and electrical illumination; Class 12 relates to hydrostatics, hydraulics, and pneumatics; and Class 13, to the production and utilisation of sound, acoustic telegraphs, the telephone, aërophone, and phonograph.

Group III.—*Applied Chemistry.*—Class 14. The manufacture of artificial products. Class 15. Bleaching, dying, and printing stuffs. Class 16. Chemical apparatus and cases of testing materials. Class 17. Chemical processes in glass manufacture, and specimens of various glass work. Class 18. Processes of raw materials employed in porcelain manufacture, with specimens of the various products. Class 19. Perfumery. Class 20. Pharmaceutical and hygienic chemistry. Class 21. Wall paper and imitation leather. Class 22. Leather and hides, with their applications. Class 23. Appliances and products of the india-rubber and gutta-percha trade. Class 24. Preserved foods, and apparatus for their preparation.

Group IV.—*Applied Mechanics.*—Class 25. Mechanics applied to the liberal arts, printing and lithographic presses, voting and writing machines. Class 26. Mechanics applied to furniture and musical instruments. Class 27. Machines and tools used in morocco leather manufacture, marquetry, and toy-making. Class 28.

Goldsmith's work and clock-making. Class 29. Weaving. Class 30. Manufacture of shoes and hats. Class 31. Making nets and other appliances for fishing. Class 33 includes agricultural implements, machines, and appliances for the preparation of food. Class 34 is restricted to mining and metallurgical plant, including steam-engines, models of underground workings, appliances for the driving of tunnels, foundations by means of compressed air, furnace bars with water circulation, metals, alloys, and specimens. Class 39 embraces the plant of chemical works, paper mills, and dye works, new motors, utilisation of the force of the tides, removing incrustation from steam boilers, &c.; and Class 36, the manufacture of arms and projectiles.

GROUP V.—*Mechanics Applied to Locomotion.*—In Class 37 will be represented railway plant, permanent way, and their maintenance; steep gradient lines; improvements in railway carriages, their lighting and heating; steam tram-cars, locomotives working with compressed air, and traction engines; new brakes; underground lines and tunnels; and in Class 38 vehicles of different kinds employed by various nations, and velocipedes. Class 39 is devoted to navigation, and Class 40 to aëronautics; Class 41 to travelling appliances, including portable apparatus for scientific expeditions; and Class 42 to articles and products employed in the packing of goods, and lifting machinery.

GROUP VI.—*Applications of Natural Science* (Class 43) *to Agriculture and Horticulture, and* (Class 44) *to Forestry.*—Class 45 relates to the various natural products employed in industry; Class 46 to the utilisation of textile fibres, basket work, straw paper, and cardboard; Class 47 to artificial flowers, fruits, and shrubs; Class 41 to natural history, with appliances for the taxidermist; Class 49 to useful and injurious insects, with methods for the destruction of the phyloxera. In Class 50 will be found specimens of alimentary substances. Class 51 relates to pisciculture, Class 52 to fisheries, Class 53 to non-alimentary sea produce; Class 54 to medical science and instruments, and the acclimatisation of cinchona and the eucalyptus in Africa and the South of France; Class 55 to surgical science and instruments; and Class 56 to dentistry. Class 57 covers the wide field of sanitary science, individual and general, comprising discoveries relating to hygiène and the well-being of the working classes, baths, gymnasiums; public and private closets, the purification and utilisation of water, sluices and sewers; appliances connected with highways and systems of paving; fire-engines and fire signals; waterworks and mains; matters relating to hospitals and models; and, finally, appliances for cremation.

GROUP VII.—*Mathematical Instruments* for (Class 58) measuring, dividing, and calculation; (Class 59) astronomy and navigation, including balances, weights and measures; (Class 60) astronomy; (Class 61) meteorology, and (Class 62) horology, including astronomical clocks and chronometers, public clocks and their illumination, pedometers, &c.

GROUP VIII.—*Geology* (Class 63) applied to agriculture and (Class 64) industry; artificial stone and raw products for ceramic art, with specimens. Class 65 includes mineral fuels and exploring plant, works for obtaining a water supply, artesian wells. Class 66. Precious stones. Class 67. Geological and palæontological collections, plans, and sections.

GROUP IX.—In Class 68 will be found books, manuscripts, and designs relating to the classes of the exhibition; while Class 69 will consist of replics to a series of questions, addressed to each exhibitor, either introduced or under consideration.

GROUP X. has already been noticed.

GROUP XI. embraces a loan collection of artistic and industrial objects, and also temporary exhibitions of flowers, fruit, and vegetable.

A small charge is made for space, from which, however, public bodies, scientific societies, and workmen are exempted; but only such objects as are distinguished by some merit, interest, or superiority, are to be admitted. Congresses will be held, and lectures given upon subjects connected with the exhibition. A jury will be nominated, partly by the committee of management, and partly by the exhibitors, for awarding the prizes, which will consist of diplomas of honour, and of gold, silver-gilt, silver, and bronze medals, and hon. mentions. The office is at the Union des Chambres Syndicales, Rue de Lancry, Paris; and Messrs. Emile, Caspar and Co., of 73, Great Tower-street, E.C., are authorised agents for Great Britain. The time for receiving applications for space from English exhibitors has been extended to the end of February; and the exhibition is to be open from the 24th July to the 25th November.

THE ELECTRIC LIGHT AT WESTGATE-ON-SEA.

During the month of December, last year, an interesting experiment in electric lighting, on a practical scale, was carried out at Westgate-on-Sea, at the instance of Mr. Edmund F. Davis, of St. Peter's, Isle of Thanet. A considerable portion of Westgate is owned by Mr. Davis, and so are the gas works at Birchington, which supply Westgate with light. Mr. Davis was desirous on private, and no less on public grounds, of solving the problem of gas *versus* electricity for lighting purposes, and placed the matter in the hands of Mr. W. H. Bennett, C.E., and Mr. W. A. Valon, C.E., to test. Those gentlemen have lately issued a voluminous report giving the results of the trials, and from that document the following particulars are taken:—The Jablochkoff electric light was selected from amongst the others now before the public, and six lamps were fitted up in the Sea-road. They were placed 80 feet apart, and each contained four Jablochkoff candles, the current being produced from a six-light Gramme machine, which was driven by a portable engine of 10-horse power nominal, made by Messrs. Garrett and Co. There were two attendants, one for the engine and the other for the machine and the lamps. The current was divided into two circuits, three lamps being placed on each circuit. The experiments commenced on the 2nd of December, and were continued for 24 nights, the lamps being lighted for four hours each night, thus giving a total of 96 hours. Upon eight occasions during the trials, candles went out, which is attributed to faulty carbons. Each time a lamp went out, all the others on the same circuit were also extinguished. A number of photometric experiments were made to test the illuminating power of the electric light, and the result, as stated, is that the average illuminating power of each lamp is equal to 197 candles. The electric light being transmitted through an opalescent glass globe, as on the Thames-embankment, is of course deprived of its normal power to a considerable extent.

With regard to the cost of the electric light, Messrs. Bennett and Valon report that the working expenses for the 24 days amounted to £40 9s. 4d., and this sum includes fuel, water, oil, 586 Jablochkoff candles at 8d. each, and the wages of the two attendants. As each lamp afforded a light equal to 197 candles, it follows that the illuminating power of the six was equal to 1,182 candles. To produce the same amount of light by gas of the same quality as that at Westgate, would require 107½ ordinary street gas-lamps, each burning five cubic feet per hour, which, of the Westgate quality, would equal 11 candles, and, at the Westgate price of 6s. 6d. per 1,000 cubic feet, would cost £16 15s. 4d. for the 96 hours. This shows a balance of £23 14s. in favour of gas at the Westgate high price, but, calculated on the basis of the London price, which is 3s. 6d. on the average, the cost would only be £7 18s. 9d. for gas, as against £40 9s. 4d. for the electric light. In the electrical experiment, the cost of fuel, water, and oil alone was £7 14s. 8d., which

is almost exactly that of the gas as calculated upon the basis of London prices. In order to show the cost of establishing and working six electric lamps for a year of 4,327 lighting hours, upon the basis of the cost of the Westgate experiments, Messrs. Bennett and Valon include the necessary estimates in their report. The buildings, plant, and machinery are put down at £1,522, whilst the working expenses—including interest on that sum at 10 per cent., and depreciation on one set of machinery and lamps—amount to £1,576 0s. 8d., or just upon 1s. 2½d. per light per hour for the 4,327 lighting hours. This is exclusive of interest on working capital and depreciation of buildings and cables. The cost of supplying the same illuminating power with gas, at the Westgate price, is £775 17s. 4d., or, including lighting, cleaning, and repairing, £825 14s. 10d. At London prices, and including lighting, cleaning, and repairing, the cost would only be £427 13s. 3d. In concluding their report, Messrs. Bennett and Valon observe that the exhibition of the electric light, as such, was, at Westgate, most successful. At the same time, they state that that method of illumination is surrounded by so many practical difficulties, that no amount of improvement is likely to fit it for adoption. They observe that the liability of the machinery to derangement at any moment, the defective character of the candles, the incessant variation of the illuminating power, want of diffusibility and means of storage, the constant care and attention the lights require, and the enormous cost of producing the light—all unfit it for use as a general public illuminating agent. Mr. Davis deserves great praise for the spirited manner in which he has gone into the matter, at his own expense, and for having made the results public. To Messrs. Bennett and Valon much credit is also due for the careful manner in which they conducted the experiments, as shown by their report.

CORRESPONDENCE.

A NEW MATERIAL FOR PAPER.

Referring to the extract from the *Times*, under the above heading, in a recent *Journal*, I very much doubt whether a single ounce of "Mogador Esparto" ever entered into the composition of the paper supplied to that journal; if, and when esparto is used, it will only be the very best "Spanish," the bulk of such a quality of paper consisting of rags, to give the requisite degree of tenacity and strength which we paper-makers know, esparto, unfortunately, does not possess.

Whether, from the character of the soil, or climate of Morocco, or possibly because the Atochas (stools or clumps) have not been sufficiently cropped, I cannot say, but the fact remains that "Mogador Esparto" is decidedly the lowest quality of any esparto that comes into the market.

The *Molinia cœrulea* referred to, containing less silica than either esparto or straw, requires less severe chemical treatment, bleaches readily, and gives a fair yield; what sort of paper it would make requires practical working to determine, as I can only speak from laboratory experiments, the quantity sent me by Mr. Christie for investigation being very small.

I coincide, however, with Dr. Cameron in opinion that the *Molinia cœrulea* (blue moor-grass) is probably more valuable for local consumption, as a food product for cattle, than for paper-making, especially having regard to the cost of collecting, drying, packing, and carriage, on an exceedingly light and bulky material; indeed, my conviction is that no raw fibrous material can be grown in England for paper-making purposes to pay, and although straw is now (for lack of other material) pretty extensively used, it must be remembered it is only locally available, and in abundant seasons as a waste, or by product, its cost of cultivation being covered by the grain produced.

In view of the present scarcity and advancing cost of esparto or alfa, it is high time some other fibre was introduced, especially as wood pulp and some other ingredients that now (of necessity) enter into the manufacture, it must be admitted, do not tend to improve its quality. Thomas Routledge.

Clanheugh, Sunderland.
3rd Feb., 1879.

OBITUARY.

Peter Le Neve Foster, M.A.—The members of the Society will have been made aware, by the announcements in the daily papers, of the severe and unexpected loss which has befallen the Society by the death of Mr. Le Neve Foster. Though Mr. Foster had attained to a good age—he was in his 70th year when he died—none of his many friends had any anticipation that he would not, for some time yet, be able to continue the work at which he had been so long engaged. Since Christmas last he had been confined a few days by an attack of gout, but it was hoped that the illness had left him, for he was apparently quite restored to health, and he was able to resume his duties at the Society, which had been for a short time interrupted. However, on Thursday, the 20th inst., shortly after his return to his own house at Wandsworth, he was seized with a sudden attack of syncope, the result of fatty degeneration of the heart. There were no previous symptoms of anything seriously wrong, till a member of his family, coming into the room where he had been sitting by himself for a few minutes reading the newspaper, found that he had fallen back from his chair, dead. So little expected was the attack, that he had finished his ordinary day's work at his office, and had even walked up from the railway station to his own house about one hour before his death. During the day, none of the friends who saw him noticed any alteration in his manner or appearance, nor was there the slightest warning of his so sudden end. Mr. Foster was born on the 17th August, 1809, and was the son of Mr. Peter Le Neve Foster, of Lenwade, Norfolk. He was educated under Mr. Valpy, at the Norwich Grammar School, from whence he proceeded to Trinity Hall, Cambridge. After having taken his degree as thirty-eighth wrangler in the Mathematical Tripos of 1830, he was elected Fellow of his College. He was called to the Bar at the Middle Temple in 1836, and practised as a conveyancer till he became Secretary to the Society of Arts in 1853. Previous to his appointment as secretary, Mr. Foster had been connected intimately with the Society. His father had been a member as early as 1807, while, even before this, in 1800, his grandfather, Mr. A. Osorio, had joined it. This gentleman was a very active member, serving on committees, and taking a considerable part in the Society's work. Its future secretary became a member in 1837, on the proposal of Mr. (afterwards Sir) W. H. Bodkin. Later on he served upon the Council, and also filled the office of treasurer in 1850 and 1851. On Mr. Grove's leaving the Society of Arts to take the secretaryship of the Crystal Palace, Mr. Foster resigned his seat on the Council, and became secretary in his place. It is needless to say that since that time all the work of the Society was conducted through him alone. Work of so varied a character left little leisure for other pursuits, and so it is in the records of the Society and in those alone, that we must look for the history of Mr. Foster's later life. It would be impossible to particularise any portion of the Society's action with which he was more specially connected than with all the rest. It might almost be said that in every department of it he took an equal interest, and, at any rate, to each one he loyally devoted his powers and his

time. How much of the success gained by the various movements of the Society was due to Mr. Foster can, indeed, never now be known, for he was ever ready to do the work without seeking to obtain for himself the credit that was often his due. His individual contributions to the Society's proceedings are to be found in every volume of its *Journal*. The principal were the two papers he read, one on "Aluminium," in February, 1859, and one on "Figure Weaving by Electricity," in February, 1860. Mr. Foster was intimately associated with all the earlier international exhibitions. He was appointed to carry into effect the provisions of the Act for the protection of inventions in the Exhibition of 1851, and was also named treasurer for payment of all executive expenses in the original Commission. With the arrangements for holding the Exhibition of 1862 he was, of course, connected from the beginning, since, as is well known, these were in the first instance entirely in the hands of the Society. He was also secretary to the department of photography in that exhibition. The Moscow Exhibition in 1872 he was closely associated with, as its business in England was managed by a committee of the Society. With that of Dublin in 1865 he was also connected, though not so closely, but he was one of the committee, and took an active share in its working. In the same way he may be said to have had part in all the various exhibitions previous to that of Vienna. From his boyhood upwards Mr. Foster took a keen and enlightened interest in many branches of science. He was one of the first to practice, as a scientific amateur, the art of photography, and on this subject he has written a good deal in the pages of the "British Journal of Photography," and other periodicals; he also wrote the article on "Photography," in the series of volumes on "British Industries," edited by Mr. Phillips Bevan. He was one of the founders of the Photographic Society, and served on its Council for many years. He was President of the Quekett Microscopical Club for a year. From 1863 to 1866 he served on the Council of the British Association, the meetings of which he has attended regularly for the past twenty years. For thirteen years he acted as Secretary of the Mechanical Section of the Association, the last time being at the meeting at Brighton in 1872. Mr. Foster was married, in 1838, to the third daughter of the Rev. C. Chevallier, Fellow and Tutor of Pembroke, Cambridge, and a man of some University distinction, Chancellor's Medallist, &c. There were eight sons and two daughters born of the marriage, all of whom are now alive. Mrs. Foster also survives her husband. Mr. Foster was a corresponding member of the Société d' Encouragement of France and of the Netherland Society for the Promotion of Inventions. He was a Knight of the Tunisian Order of Iftikar, and of the Italian Order of the Redemption. Of Mr. Foster's special personal qualifications for the post he filled so long and so ably, few who knew him will need to be reminded. His kindly, genial nature, his readiness to receive and assist all the many applicants who came on such divers errands to the Society, made him loved and liked by all with whom he came in contact. Those who knew him most intimately will be best aware that they will have to seek long before they find such another friend — so kind, so helpful, and so willing. Few men had a larger circle of acquaintances; none could pass away with kindlier wishes, or amongst more sincere regrets. Though he lived to a ripe old age, an age at which many men would be seeking rest from the cares of work, no one ever seemed to think that it was time for Mr. Foster to be getting rid of the troubles of office, he was so full of life and vigour. The very day of his death he was busy with the preparations for the coming Conference by the Society on "Health," a subject in which he had for the last few years taken a special interest. The many friends who have contributed to the testimonial recently proposed to mark the completion of a quarter of a century's service to the Society (a fifth of the whole term of the Society's existence), will be glad to learn that, though he was destined never to receive it, its satisfactory progress was known to him, and was a source of very great gratification. It has been suggested, and the suggestion will certainly be acted upon, that a fresh effort should be made to increase the fund collected, now that a stronger appeal can be put forth than was at all called for in the case of what was but a complimentary expression of kindly feeling, but is now likely to be a valuable assistance where it will certainly be wanted.

GENERAL NOTES.

Ostriches in Australia.—The last report of the Acclimatisation Society of Victoria contains some interesting particulars concerning the attempts to introduce the industry of ostrich breeding into that colony. Three or four nests of eggs were laid, some of which were hatched out by the parent birds in the ordinary manner, while others were entrusted to the incubator, which has proved so successful in South Africa, where it has almost entirely superseded hatching by natural means. By both the natural and the artificial methods of incubation the young ostriches were safely hatched, but the hopes which were thus raised of rearing a large flock of birds were destroyed, the chicks being killed either by sudden storms of rain or by a disease which has been observed to attack the birds in South Africa as well as in Australia. The young chickens exhibit the first symptom of illness by appearing unsteady on their feet, and this gradually increases till they are at length unable to stand still, and must either keep moving about rapidly or fall to the ground. The appetite all the time keeps as good as ever, and remains so until near the end, when the birds, worn to a skeleton by constant running, fall to the ground, are unable to rise, and die. In some cases death has not ensued for some months, but scarcely any ostriches so attacked have been known to recover. An examination after death of several specimens has shown the feet and legs to be extensively congested, but the vital organs to be quite healthy. Misfortunes attended all the attempts to rear a brood of birds, both at Murray Downs and on Sir Samuel Wilson's estate on the Wimmera. Last year a brood of young ostriches was hatched out, but an eagle carried off two or three; two others were killed by the male bird, one died of disease, and only two were in health at the time of the presentation of the report. Nineteen birds in all remained in the possession of the Acclimatisation Society at the end of last summer, and, with the experience gained, it is hoped that they may be fully acclimatised and become ultimately a source of profit. The old birds have been plucked on two or three occasions; one small parcel of feathers, being sent to London, realised £26, and they were "pronounced superior to any of the Cape feathers." Unfortunately, the method of cutting the quills with a sharp knife was not adopted, and the birds suffered somewhat in consequence; but in future the Cape method of cutting, instead of plucking, the feathers will be followed.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at Eight o'clock:—

MARCH 5.—"The Social Necessity for Popular and Practical Teaching of Sanitary Science." By JOSEPH J. POPE, Esq., M.R.C.S., L.S.A.

MARCH 12.—"The Compensation of Watches, Clocks, and Chronometers." By EDWARD RIGG, Esq., M.A.

MARCH 19.—"Economical Gardens for Londoners." By W. MATTIEU WILLIAMS, Esq., F.R.A.S., F.C.S.

MARCH 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor

Barff, M.A. F. A. Abel, Esq., C.B., F.R.S., will preside.

April 23.—"English Fresh-water Fisheries." By J. Willis-Bund, Esq., Chairman of the Severn Fishery Board.

African Section.

Tuesday Evenings, at Eight o'clock.

March 18.—"Africa, a Paramount Necessity for the Future Prosperity of the Leading Industries of England." By James Bradshaw, Esq., of Manchester. Sir T. Fowell Buxton, Bart., will preside.

After the reading of Mr. Bradshaw's paper there will be a general discussion on the various schemes that have been proposed for the introduction of trade and civilisation into the interior of Africa.

April 1.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

April 29.—"Some Remarks upon an Old Map of Africa contained in Janson's Atlas, published at Paris in 1612." Communicated and exhibited by R. Ward, Esq.

Chemical Section.

Thursday Evenings, at Eight o'clock.

March 13.—"The Injurious Effects of the Air of Large Towns on Animal and Vegetable Life, and on Methods Proposed for Securing Salubrious Air." By W. Thomson, Esq., F.R.S.E.

Indian Section.

Friday Evenings, at Eight o'clock.

March 7.—"The Plants of India adapted for Commercial Purposes." By John R. Jackson, Esq., Kew Museum.

Cantor Lectures.

The Second Course will be by Dr. W. H. Corfield, M.A., on "Dwelling-houses: their Sanitary Construction and Arrangements."

Lecture III.—March 3.

Water Supply.—Sources, systems of service, cisterns, pipes, filters, &c.

Lecture IV.—March 10.

Removal of Refuse Matters.—Dust, kitchen refuse, earth-closets, &c. Conservancy and water-carriage systems compared.

Lecture V.—March 17.

Sewerage.—Main sewers and house branches, traps, ventilation, &c.

Lecture VI.—March 24.

Water-closets, Sinks, and Baths.—Arrangements of pipes, traps, &c.

N.B.—The Course will be illustrated by specimens and models from the Parkes Museum of Hygiene.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. W. H. Corfield, "Dwelling Houses; their Sanitary Construction and Arrangements." (Lecture III.)
Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Mr. W. Scotson, "The Present Aspect and Future Prospects of our Home Agriculture."
Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.
Society of Engineers, 6, Westminster-chambers, 7½ p.m. Mr. Joseph Bernays, "The New Pits and Hauling Machinery for the San Domingos Mines in Portugal."
Royal United Service Institution, Whitehall-yard, 8½ p.m. Dr. C. W. Siemens, "Recent Advances in the Production and Applications of Steel, having reference especially to Naval and Military Construction."
Medical, 11, Chandos-street, W., 8½ p.m.
Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. Prof. T. McK. Hughes, "The Evidence already obtained as to the Antiquity of Man."
London Institution, Finsbury-circus, E.C., 5 p.m. Dr. J. Milner Fothergill, "The Moral Lessons of Physiology."
Social Science Association, 1, Adam-street, Adelphi, W.C., 8 p.m. Mr. Henry Kimber, "The Bankruptcy Law and its Administration."

Tues....Central Chamber of Commerce (at the House of the Society of Arts), 11 a.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture VIII.)
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Discussion on "Heavy Ordnance."
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.
Biblical Archæology, 33, Bloomsbury-street, W.C., 8½ p.m.
Zoological, 11, Hanover-square, W., 8 p.m. 1. Mr. L. Taczanowski, "Liste des Oiseaux Recueillis au Nord du Perou, par MM. Stolzmann et Jelski, en 1878." 2. Mr. R. Bowdler Sharpe, "Some Collections of Birds from Kina-Balu Mountain, in North-Western Borneo." 3. Mr. F. Jeffrey Bell, "Observations on the Characters of the Echinoidea. Part I. The Species of the Genus *Brissus* and on the Allied Forms *Mooma* and *Metalia*."

Wed....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. Joseph J. Pope, "The Social Necessity for Popular Practical Teaching of Sanitary Science."
Entomological, 11, Chandos-street, W., 7 p.m.
Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.
Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Dr. Phené, "The Cave of the Oracle of Delphi." 2. Mr. E. W. Dymond, "The Stone Circle at Gunnerheld."
Obstetrical, 53, Berners-street, Oxford-street, W., 8 p.m.

Thur....Royal, Burlington-house, W., 8½ p.m. 1. Mr. J. Ward, "Observations on the Physiology of the Nervous System of the Crayfish (*Astacus fluviatilis*)." 2. Mr. P. H. Carpenter, "Preliminary Report upon the Comatulæ of the *Challenger* Expedition." 3. Prof. Huxley, "The Character of the Pelvis in the Mammalia, and the conclusions respecting the Origin of Mammals which may be based upon them."
Antiquaries, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W., 8 p.m. 1. Mr. G. R. Mline Murray, "*Bacterium lactis*." 2. Mr. Edward J. Miers, "Classification of the *Maioid Crustacea*, or *Oxyrhyncha*."
Chemical, Burlington-house, W., 8 p.m. 1. Mr. G. Attwood, "The Quantitative Blowpipe Assay of Mercury." 2. Mr. T. W. Thomas, "Gas Analysis and Gas Apparatus." 3. Mr. Watson Smith, "The Isomeric dinaphthyls." 4. Mr. T. M. Thomson, "The Action of Isomorphous Salts in Exciting the Crystallisation of Supersaturated Solutions of each other."
London Institution, Finsbury-circus, E.C., 7 p.m. Mr. E. B. Nicholson, "English Pronunciation."
South London Photographic (at the House of the Society of Arts), 8 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Tyndall, "Sound." (Lecture IV.)
Royal Society Club, Willis's-rooms, St. James's, S.W., 6 p.m.
Archæological Institution, 16, New Burlington-street, W., 4 p.m.

Fri. ...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. John R. Jackson, "The Plants of India Adapted for Commercial Purposes."
Royal United Service Institution, Whitehall-yard, 3 p.m. Major-General Sir Frederic J. Goldsmid, "Persia, and its Military Resources."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m., Prof. Huxley, "Sensation, and the Uniformity of Plan of Sensiferous Organs."
Geologists' Association, University College, W.C., 8 p.m.
Philological, University College, W.C., 8 p.m. 1. Mr. H. Nicol, "The Old French Vowel End Law." 2. Mr. H. G. Leland, "The Gipsy Language."
Royal College of Physicians, Pall-mall East, S.W., 5 p.m. (Gulstonian Lectures.) Dr. Curnow, "The Lymphatic System and its Diseases." (Lecture I.)

Sat......Medical, 11, Chandos-street, W., 8½ p.m. Anniverary.
Physical, Science Schools, South Kensington, S.W., 3 p.m. Profs. Ayrton and Perry, "A New Theory of Terrestrial Magnetism." 2. Dr. J. Hopkinson, "Some Experiments with the Quadrant Electrometer." 3. Mr. F. D. Brown, "The Maintenance of Constant Temperatures and Pressures."
Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Mr. Walter H. Pollock, "Colbert and Richelieu." (Lecture I.)

JOURNAL OF THE SOCIETY OF ARTS.

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FRIDAY, MARCH 7, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

APPOINTMEMT OF SECRETARY.

At their meeting on Monday last, the 3rd inst., the Council appointed Mr. H. Trueman Wood, the Assistant-Secretary of the Society, to the post of Secretary, vacant by the sudden death of Mr. Le Neve Foster.

THE LATE MR. LE NEVE FOSTER.

At the meeting of the Council held on Monday, the 3rd inst., the following vote of condolence with Mrs. Le Neve Foster and her family was passed:—

"The Council desire to convey to Mrs. Foster the expression of their deep and heartfelt sympathy and condolence on the decease of Mr. Foster, their late Secretary. The efficient services performed by Mr. Foster during the 25 years he was Secretary of the Society have been of a character to place him in a foremost position as one of its chief benefactors. Since the time he first assumed the post of Secretary it has quadrupled its numbers, its income has increased, its sphere of usefulness has proportionately enlarged; while, from his assiduity in the performance of his duties, and his geniality and kindness of manner, he gained the respect and admiration of a large circle of friends. The Council feel that in his death they have lost one of the best of Secretaries, and one whom it will be difficult to replace."

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference will be held in the Rooms of the Society of Arts, on Thursday and Friday, the 15th and 16th May, 1879, on National Water Supply, Sewage, and Health, the Right Hon. James Stansfeld, M.P., late President of the Local Government Board, in the chair, assisted by the members of the Executive Committee:—Lord Alfred Churchill (Chairman of Council); Sir Henry Cole, K.C.B.; Colonel Sir E. Du Cane, K.C.B.; Captain Douglas Galton, C.B., F.R.S.; Mr. F. A. Abel, C.B., F.R.S.; Mr. T. W. Keates; Dr. Voelcker, F.R.S.; Mr. W. Hawes, F.G.S.; Major-Gen. F. Cotton, R.E., C.S.I. Papers relating to the above subjects will be read and discussed.

Programme of Proceedings.

The Conference will meet each day at 11 a.m., and sit till 1.30, then adjourn till 2, and sit again till 5 p.m., and, if necessary, meet again at 8 p.m.

Thursday, 11 a.m.—Opening of the Proceedings by the Chairman.
Papers and Discussion.

Friday, 11 p.m.—Proceedings will be resumed.
Papers and Discussions continued.

There will be an Exhibition of Mechanical and Chemical Apparatus in connexion with Water Supply, Treatment of Sewage, and Health. All articles for exhibition must be delivered, carriage free, not later than Saturday, the 10th May, 1879. Manufacturers and others desiring to exhibit should communicate forthwith with the Secretary of the Society of Arts.

Papers on any of above heads are requested.

The object of the Conference is to discuss existing information in connexion with the results of any systems already adopted in various localities, referring to the subjects of National Water Supply, Sewage, and Health; to elicit further information thereon; and gather and publish, for the benefit of the public generally, the experience gained. The introduction and discussion of untried schemes will, therefore, not be permitted. The papers accepted for the Conference will be printed and circulated at the Meetings.

Prize Medals.

1. The Council of the Society of Arts offers one Gold and three Silver Medals for the best suggestions, founded upon evidence already published, for dividing England and Wales into districts, for the supply of pure water to the towns and villages in each district.

2. The districts should be laid out on a skeleton map scale, which can be obtained from Mr. Stanford, 55, Charing-cross, price 6d. each.

3. The average rainfall in the district should be stated; also the population of the district, and its geology.

4. The suggestions should be written on foolscap, half-margin, and sent, accompanied by maps, under cypher, to the Secretary of the Society of Arts, on or before the 26th day of April, 1879.

5. The maps will be exhibited, and the suggestions will be discussed at the Conference on National Water Supply.

6. The Council will invite the assistance of eminent authorities to recommend the competitors worthy to receive the prizes; but the prizes will be withheld if the suggestions made do not appear to the judges to be of sufficient merit.

THIRTEENTH ORDINARY MEETING.

Wednesday, March 5th, 1879; Dr. B. W. Richardson, F.R.S., Member of the Council, in the chair.

The following candidates were balloted for and duly elected members of the Society :—

Bray, George, Blackman-lane, Leeds.
Harrison, Robert Henry, Ware, Herts.
Johnson, James Henry, Albert-road, Southport.
Kirkham, Professor T. B., Bombay.
McHardy, Coghlan, 1, Grenville-place, Cromwell-road, S.W.
Pym, Wollaston F., Junior Carlton Club, Pall Mall, S.W.
Somerset, Rear-Admiral Leverson Elliot Henry, 44, Curzon-street, Mayfair, W.

The paper read was—

THE SOCIAL NECESSITY FOR POPULAR AND PRACTICAL TEACHING OF SANITARY SCIENCE.

By Joseph J. Pope, M.R.C.S., L.A.C.,

Staff Surgeon (half-pay), Professor of Hygiene to the Birkbeck Institution.

Mr. Edwin Chadwick recently made a statement, that 120,000 preventable deaths annually occur in in England and Wales. This may well startle and claim our attention.

In the first place it assumes that the causes of these deaths are well known, and have been recognised; and secondly, that they are capable of satisfactory removal. It points at the same time in an unmistakable, yet lamentable, manner to the apathy and indifference with which we, as a people, have for so long a time possessed such knowledge, and failed to avail ourselves of its vital experience and humane lessons. Some may say matters have changed, and I am prepared to hear that the subject of sanitation is now receiving a fair modicum of attention. I may be told that, both in Parliament and municipality, an anxious endeavour now shows itself to recognise more pointedly the laws of health, and to enforce their observance, and to a degree this is probably so, but in my opinion such legislation bears but little fruit, and *per se* is not likely to produce any more successful results in the future than it has achieved in the past.

The sanitary laws in this country, viewed in the aggregate, are useless, and comparatively inert; and this mainly arises from the fact that the generality of people still view sanitary reform with indifference, and as quite irrelevant to the ordinary needs of life.

Very few people, indeed, consider the subject of their own health, until warned by a present attack of sickness, through failing to acknowledge the true worth of science and medicine, which is far more preventive than remedial. Can it be doubted that it is better and wiser to abolish the cause of disease, to prevent its appearance, than to wait for its attack and cure the result? This desirable condition of things will never be attained unless the value of health is fully recognised by every member of every household. The people are positively ignorant of the simplest sanitary laws, and do not, therefore, know the powerful aid and assistance Government has placed at their disposal.

Our condition, as a nation, renders it an impossibility to legislate for the individual. Our institutions are totally opposed to what is termed "paternal" government, and it becomes, therefore, absolutely necessary, if sanitation, with other matters, is to make satisfactory progress, that the individual should be educated to avail himself of the facilities provided by our system of law making, which deals, not with persons, but communities; not with houses, but with towns and districts. That is our present true need, the education of the people, so that they may recognise the value of health, and know that, in most cases, illness and disease result from their own follies and mistakes, or wilful disregard of the ordinary rules of morality and the commonest of sense.

The social economy of the Jews, which is believed to be of Divine origin, paid the most minute attention to the physical well-being of the people, certain requirements being exacted from the individual, some bearing upon his own person, others dealing with his relation to his fellow-man. The well-known motto, "Take care of Number One," is not, as many suppose, a selfish one. It deserves more thought than many seem to bestow upon it. The man who is mindful of his own health will not disregard that of his neighbours, but, by example and influence, if not by teaching and precept, he will endeavour to establish healthy principles amongst the community.

A gentleman once, about to cross a ferry, called out to the watermen "who can swim?" A dozen of them replied "I can, sir," but observing one man slinking away, the gentleman went after him and stopped him, when he said, "Sir, I cannot swim;" "Then you are my man," replied the gentleman, "for you are sure to take care of me for your own sake."

It is only in the personal and practical application of sanitary knowledge that we can secure its advantageous and proper results.

A town may be supplied with an abundant and pure source of water, and the inhabitants may fail to reap much benefit. The Corporation may erect works, baths and washhouses, and even give every house a constant supply; it will be of but small use if the inhabitants do not recognise the value of cleanliness.

The law provides the means for the removal of disease, but it rests with the individual to prevent it, and as the people are taught the plain unvarnished facts of sanitary science, and there is brought practically and popularly under their own observation the ease with which personal health may be secured, and the capability they possess of maintaining it, we may hope to attain that vigorous and sound condition as a nation to which we are entitled.

As we surely acknowledge that our social life should be guided by a code of moral precepts, which must be taught to and made obligatory upon every human being, so we cannot, without wilful obstinacy, shut our eyes to the facts that our physical life and its various conditions depend upon as certain laws and regulations, with which each and every one amongst us should be fully conversant. May we look hopefully forward to such a time?

In our moral code, matters formerly of tentative and exceptional nature have, by the progress of

civilisation and social development, become elevated into the position of commands, which are now recognised as binding upon every member of the community.

I need but draw your attention to the rudimentary civilisation of the Middle Ages, or the more recent examples of the customs and conduct of savage races, to show that such crimes as murder, arson, and rape, with all kinds of duplicity, were not only abundant but even tolerated and regarded with complacency. This has fortunately ceased, and we now view with horror, and punish with just severity, offences and malpractices which touch upon our moral or social relationship.

Can we not anticipate a time when sanitary crimes shall become as well known and abhorred by every section of, and individual in, the community? The domestic health, happiness, and prosperity of the people in themselves and their homes is a truly national question, and our permanence at home and abroad as a prosperous nation depends mainly upon the eradication of avoidable disease and the maintenance of our public health.

If we neglect our physical welfare, we open an easy and certain road to moral impotency. Sanitary knowledge, all-important as it is, requires to be practically and popularly demonstrated. It is not merely a subject for a class, but for all and every one. Neither old nor young, rich nor poor, male nor female, should remain in ignorance of such valuable and vital truths; and, further, they must all view it as knowledge for present and continual use, not to be retained for future advantage. It is different to our ordinary system of education, which looks ahead for any advantageous result; this is something which every one can employ for themselves, and which will bring to them, individually as well as collectively, its blessings and its rewards.

The public must be made to feel that the true value of any of our sanitary legislation can only be attained through their own application of the power therein contained. Our legislation is distinctly permissive, and throws upon local bodies and communities the responsibility of preventing disease and checking mortality. Do not our local boards ignore or throw back this responsibility, thus rendering the Acts of Parliament a dead letter? Are not the hands of our medical officers of health tied down by local influences and fettered by paltry difficulties? Are they always permitted to act fairly and as they know to be right? Has it not been said to them when elected, "The less you do the better you will please"? and have not energetic measures been adopted in some instances to repress zeal, check action, and burke the publicity of proceedings?

Dr. Lankester has said:—"In London, with its fifty local boards, there is scarcely one of them which may not be charged with neglecting to carry into effect the powers which have been given them for the purpose of preventing disease and death in their midst. Their hesitation to act arises from an entire ignorance of the fundamental facts on which the life and health of their fellow parishioners depend. Read their speeches, and study their objections to spending money on any sanitary measure, and it will be at once seen that they have no right ideas on the subject of health and disease."

And again he says—"The comparatively little impression produced by the great staff of medical officers of health of London, arises from the ignorance of the population of the laws of health. This is not only so amongst the poor, but also in the midst of Boards of Guardians and select Vestries."

It may be the failing and not the fault, for the recognition of the worth of sanitary teaching makes but slow progress and scanty headway.

It is a remarkable fact, touched upon by Professor Corfield last week, that in our system of medical education we have all along omitted the subject of hygiene. Our student is taught to view and investigate the body in endless varieties of diseased conditions, but has been left in complete ignorance of what it is in a state of health; and although this fearful oversight has been recognised at last, in one or two of our principal colleges, and copying the example of the Army Boards, chairs of public health have been established, and courses of instruction afforded by competent professors, yet no examination on the subject is held to be necessary, and the matter still occupies, as it were, an extraneous and ornamental position.

What is required, and what must be done, is to educate the masses in these things, then they will insist on the beneficial adoption of sound sanitary principles, they will clamour for the enforcement of the regulations now almost in abeyance. Once let them fully understand the value of fresh air and they will submit no longer to overcrowding and the presence of noxious gases. Only clearly let them grasp the fact that sewer gas is a fatal poison, and they will insist on the builder working legitimately and the landlord acting fairly and without greed.

Then, knowing that their health is in their own hands, and that they have the power of maintaining it, they will call upon the Local Boards to arise out of their sleep, and to adopt those means which have been at their disposal for so long a time, and to enforce those laws which, although placed within their power, have been hitherto mere curiosities of legislation.

But how are we to get this education in sanitary science? First and foremost, by making it a subject in our common everyday teaching, by sowing the good seed of sanitary knowledge in the fruitful soil of a child's unprejudiced mind, and so fitting him the better to take a future part in the great struggle of life. Such instruction will prove more beneficial than many forms of present education, and will bear good fruit. It is a work wholly good; free from the error and frailty that clings to so much that we do; a work really unselfish, for it is actuated by the love of man. It should be the aim of all who have the prosperity of the State at heart. As natural science, in its familiar and various branches, becomes introduced into our system of education, so may we hope to see the nation progress in fair rivalry with others. We may not perhaps turn out so many linguists or Oriental scholars, we may not increase marked men of abstruse science and learning, but we shall multiply that glorious class, original thinkers and observers, true men and women, who will do good in their day and generation.

This education must cease to be viewed as supplementary teaching. It must also be rendered,

not as mere lessons to be learnt by rote, but as a practical benefit to be thoroughly understood and worked out. And here we meet with a serious check. Her Majesty's inspectors have so far discouraged it—they find the subject alien to their literary education; and although admonished by circular, only during last year, to afford more attention to Domestic Economy, they have only as yet lent the light of their countenances to two branches of this all important subject, namely, clothing and cookery. I would that we should not rest satisfied until it is thought of equal importance for a child to know something of his own structure, and of the simple laws governing his life, by obedience of which he can secure to himself a healthy, vigorous, and lengthened existence. And my remarks apply with even greater force to private educational establishments, and more particularly to those devoted to the education and training of girls. It is indeed a sad thought, that the largest amount of evils connected with a disregard of the ordinary laws of health can usually be found in ladies' schools, and in the general plan and arrangements for the early life of our girls. Although at her birth of equal vigour, and doubtless equal stamina, to her brother, it seems a necessary course to adopt a distinct line of conduct with reference to her. Artificial supports are thrust upon her, although she is quite able to hold herself upright. Natural freedom and healthy play are tabooed as unladylike, and sooner than she should enjoy life as it is, an artificial tone is given to her education, even from her earliest years.

It is especially woman's work to carry out the principles of sanitary science, and yet they remain the most ignorant of its simplest attributes, and neglect almost universally to take heed of its plainest requirements. Their position as housewives and mothers affords them just the opportunities beneficially to act in detecting and warding off matters likely to prove detrimental to health. As Mr. Teale pointedly put it, the wife realises keenly the dangers to her children from unsanitary conditions, the husband considering more the cost of their removal or abatement.

A not less startling fact to that quoted by Mr. Chadwick, is that one-fourth of the children born into this world to endure for threescore years and ten, die before they attain the age of five years. This is a sad truth, but it is made the more lamentable when we know that these deaths mostly arise from causes that are quite preventable, such as the unhealthy homes of the poor; the unjustifiable use of stimulants, drugs, and quack medicines; and the prejudice, ignorance, and neglect of parents and nurses. Further, we find that half the deaths occur in the first year of life. This is certainly not the necessary destiny of humanity. It is distinctly to be traced to the want of this popular knowledge of sanitary matters, for we find the majority of these are first-born children, who, under our present system, are left to be experimented upon by a fond but ignorant mother. Are there not hundreds of infants tortured and even starved to death through improper feeding? Day by day instances crop up which go to prove that on this, the first essential of a child's life, the wildest notions exist in the female mind, and the most certain methods are adopted to ensure a wretched condition, frequently having a fatal termination.

It is a sad reply, but a frequent one, to the question, "How do you feed baby?" "Oh! he has a bit of anything that is going." If for no other reason than a desire to ensure a vigorous and healthy future to us, as a nation, instruction in such a vital matter should be generally afforded, and that could be easily attained if the elements of physiology, and a practical acquaintance with the laws of health, were compulsory subjects in every girl's education.

Do not for one moment imagine that I refer merely to our poorer sisters. There are but very few of our ladies in the middle or upper classes who are at all aware of the causes of domestic unhealthiness.

In the simplest matters of fresh air and sanitary cleanliness we can find wilful neglect. Walk along our streets and squares in the west-end of London and see how many windows are open, and how many will open at the top. Let us go into the mansion, and shall we not find the stuffy close smell of an ill-ventilated house; ome rooms shut up and derived of air and light because not immediately in use; a thick carpet on the bedroom floor carefully tacked down, and perhaps even extending under the massive bedstead itself; the carpets loaded with dust and organic impurities, and the bed surrounded with massive cornice and heavy curtains, certain obstacles to fresh air, and undoubted receptacles for further injurious materials?

Then, have we not the lumber-room and under-stairs cupboard, full of incongruities, kept hidden away, to fester and ferment? How often shall we find the children in close nurseries and bedrooms, fashionably, but dangerously, clad, and yet further exposed to evils from gaslight and stove, and the artificial education thought to be necessary for their social position. Sanitary maxims are, in many parts of England, as much strangers in the drawing-room as in the cottage.

Now another important point upon which we find much ignorance, and often most reprehensible carelessness, is that of the prevention of the spreading of infectious disease.

During the past year I have met with some striking instances. I was lecturing at Bristol upon sanitary matters, when the following case occurred. The gardener of the gentleman with whom I was staying, reported that his children had measles, and that he had discovered the cause to be the children of a charwoman living near him who were suffering from this infectious disease. He said, "I told her she ought to keep her children at home and by themselves;" but she replied, "Oh! dear me, why? If it was known they had anything catching, I should lose my work, and I really didn't know it was measles, that I didn't; I thought it was only scarlet fever!"

I was in a barber's shop last month, and hearing a little boy cough, so as at once to tell me he was suffering from whooping cough, I remarked so to his father. "Oh, yes," said he, "they are all getting it at school." I found he and his sister were going to a neighbouring Board school, and had done so all through the attack. How many lives were put in jeopardy through the careless

ignorance of that barber and his wife, and, I fear, the culpable indifference of those school authorities! I think there is no stronger claim for teaching sanitary science than the fact, that it is only by the universal instruction of the people we can hope for the adoption of measures of precaution to ward off disease, and at once check its progress if it makes its appearance. And why shall we wait for another generation to obtain these benefits? We have a goodly audience always around us. It is no use to abuse existing conditions without offering some suggestions for their improvement, and it is certainly necessary to open the eyes of those who voluntarily submit to evils, and throw away their lives.

How, then, can we teach sanitary truths popularly to our fellow men and women? By example and precept. If every one would but earnestly carry out what they know, very many would be led to follow in their footsteps.

In the clergy we should find mighty coadjutors. They have, perhaps, the largest opportunities of inculcating good sanitary principles. Let them at once determine to understand those principles themselves, and they will have, in that natural knowledge, quite as powerful an agent for good as in their spiritual ministrations. As Mr. Spurgeon quaintly put it to an audience I was about to address on "Fresh Air," "You should have the grace of God, but you should have also oxygen. You cannot appreciate the one unless you obtain the other." From the pulpit our clergy can tell the mass of the people how necessary it is to recognise the laws of life as God's laws, that it is as wilful a crime to neglect the proper care of the body as it is by immorality or other sin to jeopardise the soul, and he can show how much better it is to prevent disease than to relieve suffering, to lengthen life than to comfort the bereaved.

They also have more influence in education than any other class, and in schools and colleges can exercise that influence for much good, urging on both committee and master the introduction of such vital instruction, and even under certain circumstances becoming themselves the teachers of these important facts.

Then, in the house-to-house visitation, no one has better opportunities for personally advocating sanitary knowledge and improvements, and I can but feel that in supporting any effort in that direction they fitly fulfil their high duty "as followers of Him whose quick compassion led Him to heal all manner of ills."

As an old pupil of such a thorough exponent of sanitary science as our esteemed Chairman of this evening, to whose kindly teaching and friendship I owe so very much, and as a student of later years with Professor Parkes, whose name and work in this cause can never be sufficiently acknowledged, I may perhaps be excused for thinking that the proverb, "Prevention is better than cure," is as yet but little noticed by the general mass of my professional brethren. They could materially assist in teaching the people how to keep well, but they confine their instruction too frequently to merely getting them well; their advice rarely tends to the cause of sickness and its prevention, but deals rather with its presence and immediate relief. So we find our surveyors, architects, and builders, in whose hands so much of our health, and sometimes even life depends, failing to consider the vital points in construction and arrangement of buildings. They may not know them, and I dare say many do not, but I trust the time is not far distant when they will have to know them, for the people themselves, appreciating their value and knowing their application, will insist on their adoption and observance.

Opportunities are increasing for the "middle classes" to avail themselves of instruction in sanitary matters. I believe I am right in saying that at South Kensington, King's College, the London University, and at the Birkbeck and kindred literary institutions, classes are established for the study of both physiology and hygiene. It is hoped ere long to give a distinct importance to these subjects by the opening of the Parkes' Museum, and if the already expressed intentions of the trustees and others in authority be carried out, instruction of a truly valuable kind will be fully and freely afforded.

I know of no object more worthy of support, calculated as it is to benefit the mass of mankind both in the present and in the future—a fitting memorial to one whose happiness was centered in the welfare of his fellow men, and whose life was an unceasing labour for their good. With such an opportunity for practical acquaintance with the various material connected with sanitation, and the vast choice of popular works that have now been written on the subject of health (none perhaps more popular or more valuable than those from the scientific yet ready pen of Dr. Richardson), it will be our own fault if we remain in ignorance of these valuable facts.

I cannot omit to draw attention to the interest that has been taken in the subject of Domestic Economy by the Council of the association under whose auspices we meet to-night. They have, in Congresses held at Birmingham and Manchester, done all they could to bring the importance of the matter under notice, and they will, I trust, not cease their efforts until the subject of Domestic Economy in all its branches has been efficiently and actively introduced into our systems of elementary education. I would claim for Health a prominent position, and may I be forgiven for expressing a regret that this year the subject of Health—in common with the other, but I venture to say unimportant, matters in Domestic Economy—has been excluded from a place in the Prince Consort's Prize?

I suggest that we can best reach our working classes and our poorer friends through popular lectures, with illustrations, and personal interest in districts and individual families. There are societies which undertake these plans, and amongst them I would ask permission to name that with which I am more intimately connected, "The National Health Society" (offices, 44, Berners-street) During the year 1877, considerably over 50 popular lectures were given in and around London. Last year 63 lectures were given, and having myself considerably assisted in this matter, I am able to say that the audiences have been particularly attentive and apparently most anxious to learn more and more about sanitary matters. It is also pleasing to hear that in some places good results have arisen from such lectures, and practical benefits been

already derived. The Society also encourages good work in others not directly connected with them. They offer prizes in physiology, cooking, and swimming. Teachers and scholars, both of the London Board schools and the Public Day Company's schools, have competed, and whilst the committee venture to undertake such general improvements as opening spaces for the people, utilising and adorning disused churchyards, providing seats in public places, and obtaining playgrounds for the children of crowded districts, they yet find opportunity to come nearer home, and by addressing meetings of mothers, giving them practical evidence of the best way to ventilate a room, cook the food, clothe the infant, or prevent the spread of disease, strive to popularise sanitary science in the most valuable manner.

Then we can each and every one of us assist in this good work, by personal effort. Those of you who believe in fresh air, who are cognisant of the evils of sewer gas, who feel that cleanliness and absence of dirt and refuse are advisable—having secured such blessings for yourselves, try and secure them for your neighbours. The evil influences of any neglect of the ordinary principles of sanitation cannot be localised. They will grow and spread, irrespective of class, rank, or wealth.

We forget this, I fear, and shut our eyes to the fact that, as "the wind bloweth where it listeth," it can be to us a blast of disease and misery, or the refreshing breeze of life and health. If once we can get this truth fairly acknowledged, there will be no difficulty, I feel sure, in ensuring both the practical and popular teaching of sanitary science, and in obtaining, not only personal, but Governmental acquiescence in its social necessity.

DISCUSSION.

Mr. G. Christian Mast read eleven rules of health from a German reading-book, which formed as he considered the A B C of the laws of health, and which he thought should be printed and read in schools. The rules consisted of instructions with regard to fresh air, cleanliness, exercise, bathing, temperance in eating and drinking, &c.

Mr. Hale thought the paper dealt too much with generalities, and that there was much more information on the laws of health in the rules which had just been read. He considered it a matter for regret that none of the gentlemen who came forward to teach sanitation were able to point any house which the public might inspect as an example of what a healthy house should be.

The Secretary said it might be interesting if he mentioned what the Society of Arts had been trying to do in connection with this subject. In 1876, an examination in Domestic Economy, which included Health, Clothing, Housekeeping, Thrift, and Cookery, was instituted, and in that year there were 37 candidates, 8 of whom were examined in Health; in 1877, the numbers rose to 97, 35 taking Health as their subject; and, in 1878, there were 170, of whom 60 took up Health. A considerable number were students from the Birkbeck Institution, who had profited by Mr. Pope's instructions. The Domestic Economy examinations in the Education Code were limited to girls, whilst the Society's examinations were open to both sexes. The reasons for the change in the conditions of the Prince Consort's prize were these. The subjects of examination were of various degrees of difficulty, and it was thought by the Council, after a good deal of discussion, that the subjects included under Domestic Economy were of rather an easier nature, and perhaps lent themselves more readily to cramming than some of the other subjects, such as arithmetic or languages. It was, therefore, decided that the Domestic Economy subjects should not count equally with the other subjects.

Mr. C. Cooke said that this paper was very valuable, and as an illustration of its importance, he would mention that only last week there was a letter in the *Times* complaining of the bad ventilation in Westminster-hall. He hoped that in the New Law Courts this would be seen to. There was a good plan of ventilation in the British Museum, the opening of a door opened a ventilator, and the shutting of it opened another. He thought clothing was an important part of the subject, and asked what could be more ridiculous or unhealthy than a chimney-pot hat.

Major Webber remarked that few, if any, could claim that they had always lived healthy lives, or inhabited healthy homes; but, by coming here that evening, they showed that they wanted to improve. He quite agreed, however, that it would be a good thing if there were a range of dwellings anywhere suitable for those who could only pay a small rent, which could be pointed to as models of what such houses ought to be, and he was sorry that no such buildings existed. He remembered some years ago, when the Society appointed a committee for investigating the different kinds of sanitary appliances, it was suggested that one or two small dwellings should be built and fitted up with all suitable appliances which would not be too expensive for ordinary use. It had always struck him that this was one means of instructing the public, which was much wanted, and if money were forthcoming, he thought it would be better spent in that way than in giving prizes. In the Exhibition of Paris, in 1867, there was a very useful instance of this kind of thing, in a set of model barracks, showing how such buildings could be made healthy even when crowded with men.

Mr. Blashfield thought it would be extremely difficult to lay down a law as to the building of houses. The scheme of building round London was of so independent a character that it would take a very powerful Act of Parliament to deal with it. Mr. Chadwick, some years ago, when this matter received a great deal of attention, laid down some very useful schemes for healthy dwellings of a small and cheap character, and from that time cottage building had improved to a considerable extent. It would be invidious to mention names, but in the Midland counties there were several noblemen who were building cottages of brick and stone, well-drained, and fit for people to occupy. There were also in some of the new houses being built in London excellent modes of ventilation and drainage adopted, but these were not all alike. New schemes were being brought forward almost daily, and it would not do to make one unvarying rule. Something of this sort was going on at Cambridge. There was a great scheme for ventilating the Post-office, which he had been informed was a very efficient one. Every day new schemes were proposed, and were discussed at the Institute of British Architects and similar places. Although they were often defective, he believed houses were of a better character than they used to be. An exhibition of the improvements that had taken place with reference to drainage, ventilation, gas, and water would, he thought, be very useful.

Mr. Mayer thought that good arrangements for working-class dwellings could be seen in the Peabody buildings for artisans' dwellings. He had seen it reported that the rate of mortality in those houses was

less than elsewhere, and it, might, therefore, be taken for granted that they were properly constructed with regard to health. Still, this was rather travelling away from the subject, which was how to bring the knowledge of health within popular appreciation. The suggestion made by Mr. Pope that the clergy might help, was a very good one, and if they could induce ladies to make themselves acquainted with the laws of health and to spread that knowledge among the poor they visited, they would be doing a great deal of good. He would also suggest that it should be compulsory on those who managed large schools to be acquainted with those laws, in which case they would not have such cases as they had heard of to-night, of a child suffering from whooping cough being allowed to continue at school, and several other instances of which he had heard.

Mr. M. S. Dipnall thought they were much indebted to Mr. Pope for bringing forward this important subject. The title of the paper was the "Social Necessity for some Popular or Practical Teaching of the Laws of Health." The object was not to teach the science, but to enforce its necessity by two or three tremendous examples. He had heard that day of a clergyman still living, in his 102nd year. He must have taken great care of his health—and others should do the same. Some 20 years ago, when he had more leisure than at present, he took some interest in the subject of preventable accidents, and that Society had printed a paper which he wrote on the possibility of preventing scaffold accidents. He was convinced that many lives were ueedlessly lost in this way; but he could not altogether agree with the term used in the paper, "Preventable deaths," aud thought it should rather be "Postponable deaths," because he did not believe that any philosopher had yet gono so far as to be able to prolong human life, even to a great age, still less to prevent death altogether. They could not expect to get rid of the necessity for mourning the loss of relatives, but still they might mourn them at a good old age, instead of losiug them in early years. If the clergy and the district visitors would take up this subject, no doubt an immense deal would be done towards obtaining the position of postponable deaths, which he thought was all they could look for.

Mr. R. Manuel said that Mr. Pope had alluded to a margin of legislation already provided by the State, but which, owing to ignorance or indifference, was not used. Now there was one direction in which great sanitary improvement might be made, and he wished to know whether existing legislation provided for it. In suburban neighbourhoods it was well known that when a district was laid out for building it was the practice, especially if the soil was valuable, for the speculative builder to cart it away, and fill in the space with all sorts of refuse. Now, in a sanitary sense, nothing could be more fatal to the health of a new neighbourhood than standing it on such a foundation, and he should like to know whether the power really existed of preventing the process.

Mr. Francis Cobb drew attention to the series of Cantor lectures now being delivered in that hall, which dealt practically with this subject, and at which the various sanitary appliances were freely exhibited.

Mr. Dipnall said the Metropolitan Board of Works had certainly the power of meeting the evil referred to by Mr. Manuel, by requiring houses to be built on a solid concrete foundation.

Mr. Blashfield believed district surveyors had power to prevent the throwing of rubbish round new houses, but the whole matter was under consideration, and he believed that, in the new Building Act, a great amendment would be made on this head.

The Chairman said they might congratulate themselves and the country on the progress which had been made in sanitary science since about the year 1854, when the Crimean campaign directed a great deal of attention to this matter. About that time, and three or four years later, they were beginning to move in sanitary science, but at the time to which Mr. Pope referred, when he said he was his pupil, his was probably the only systematic course in London on public health; and he thought he could then have reckoned on his fingers the number of men engaged in giving general lectures on the subject. At the present time there was this great Society encouraging lectures on health, and getting the best men they could find to give practical useful information. At the Birkbeck and London Institutions also, and now and then at the Royal Institution, the subject was dealt with, and throughout the whole of the medical schools there was a desire for similar teaching. Not only so, but there were lecturers going about to different parts of the country, and in many important institutions they found a difficulty in filling the professor's chair. This was very hopeful, and he could say from a knowledge of some of the workers in similar spheres of action in France, Germany, Italy, Spain, and America, that we were both envied and admired for what we had done in this matter. Only a week ago he received from Italy the first journal of a great sanitary institution which was being established there, and in France and Germany similar institutions were being established. We might, therefore, be well satisfied with the progress which had been made, and he congratulated the meeting on the forcible way in which the subject had been brought forward by Mr. Pope. Mr. Pope had not come there to lecture on sanitary science, but to read a paper which should raise a discussion, and in this effort he had certainly been successful. It was in this way that the public mind was educated. He should rather differ with the reader on one point, viz., where he seemed to intimate that if sanitary science were taught strictly there would be many people of common-sense and good scholars, but that the number of men of genius would decrease. He did not think they need have any such fear. In a sound body there was usually a sound mind, and the more thoroughly cultivated was the physical side of man's nature, the more certainly would there be a fine intellectual development; and as men of genius were born, not made, he should imagine they would be born quite as frequently as before, and when their bodies were thoroughly well developed there was no reason to suppose that their mental faculties would suffer. That was not the case amongst the Greeks, who paid great attention to physical development, and who produced such men as Plato and Socrates. Mr. Pope had remarked on the facility with which physiology could be taught to the young, and he had been much struck by this, as a teacher himself. He had taught some 300 or 400 ladies and gentlemen, themselves engaged in teaching; for the Gilchrist Trust, and on other occasions several times, and had found the teaching of physiology the most pleasant, easy, and useful of tasks. With reference to some prizes given from that table by Dr. Carpenter to a body of Gilchrist students in physiology, he must say that some of the answers ou anatomy, microscopical specimens, calculations regarding respiration, the strokes of the heart, and so on, were of a character which would have done credit to a class of medical students going up for their diplomas. This was very encouraging, because it had been considered, perhaps owing to the solemnity and apparent obscurity of some of the questions dealing with life, that anatomical and physiological teaching was the most difficult of all, even more abstruse than mathematics. In truth it was nothing of the sort; you could lead a class on as easily as through the alphabet. He quite agreed with Mr. Pope that the foundation must be laid in the teaching of the basic principles of life to the young, in the same manner as the teaching reading, writing, or languages; and he agreed with him, too, as to the importance, particularly of teaching girls. They were also indebted to

him for pointing out how easily epidemics were spread through ignorance. About that time last year there was a severe epidemic of whooping-cough in a London district, and he traced infection in some of the cases from a baker's shop, where two children suffering from the disease were allowed to run about, and that shop became a focus from whence it spread. You could not blame the poor people who disseminated disease in this way, because they did not know any better. Many of them laboured under the foolish impression that all children must have these epidemic diseases once, and, therefore, there was not much reason for attempting to avoid them. Medical men knew that the fewer cases there were the sooner the disease would die out, and the less severe would be the attacks. With regard to model houses, he did not believe there was a proper model house built yet, either large or small; and he thought it would be a great point gained if one perfect middle-class house could be built in London. He had had it on his mind for some time, and had made models for such a house, but other matters had prevented his carrying it out. If he did build such a house, which he still hoped to do, it should certainly be left open for some months for any one to come and see who liked.

Mr. Pope said he was much obliged to Mr. Hale, who was a living example of the necessity for this paper, since he had acknowledged his ignorance of sanitary science. If he wanted to obtain that knowledge, however, there were plenty of opportunities, either by attending the Cantor lectures, or others of a similar nature, or by giving a shilling for Professor Parkes' little book on "Personal Health." His object had been to show, that however well buildings might be erected, the people were not sufficiently instructed to value or obtain the full benefit of these sanitary improvements; and he desired to urge upon all the duty of spreading a knowledge of these matters amongst the middle and working classes. That there was a great need of it was shown by their ignorance with regard to infectious diseases; and, as the Chairman had said, you could not blame them, because they did not know. If a model house were built, he still doubted if they could trust architects or builders to copy it. If you knew your house-drains were defective, and wanted them put right, there was not a workman that he knew of who could be trusted to put them in a sanitary condition, unless you stood over him all the time; they had not been taught what was necessary with regard to the shape or size of a drain, the fall of it, and the way in which the junctions should be made. Mr. Teale, at a recent meeting of the National Health Society, showed some most extraordinary curves and junctions which had been constructed by first-class firms. It was no use having knowledge in your brains or in books, unless you could get those who had to carry out the real work of every day-life to understand it also. They all knew it was a dangerous thing for sewer gas to enter a house, and if they told their servants so, no doubt they would believe it, but to make them practically act upon this belief, you must show them clearly how it would come through a sink, if the bell trap were removed. Mind had more influence over matter than matter had over mind; and however healthy you might make a house, you might have inhabitants in it who would upset everything which was done, unless they were properly instructed. Some time ago, he was asked to devise a system of ventilation for a room where a large number of girls were employed in artificial flower making, and he did the best he could; but when he returned in a few months he found the whole of his work was useless, because every crevice and pipe had been stopped up. It was therefore necessary, in the first place, that a knowledge of sanitary science should be more generally diffused, and then there would be a chance of utilising the measures which Parliament might pass. No English law could possibly make people build houses of a certain description; but there were only certain portions of the Building Act carried out. There was no inspection of the junction of a house drain with the main sewer, and if you were dissatisfied with the sewerage of your house, you could only get the authorities to interfere on proof of injury to health—after the evil was done. There was no authority you could go to to inspect the drains, and who would insist on their being altered if they were wrong. So it was with made ground. Not long ago they got Dr. Tripe to inspect some ground at Paddington on which houses were about to be built, and he reported that this made ground was likely to prove injurious to health, and the buildings were stopped by the district surveyor; but the question was, whether this could be maintained unless the fact of its being proved injurious to health were established. Since 1855, the Vestries had had an Act which would bear materially on the building of houses, but they did not carry it out, and would not until the public made them. If all the people in London knew what sanitary improvements were, they would make the Vestries enforce the Acts, and that was what he wanted to see done. He would only add that he had often lectured on clothing, and had not worn a tall hat for many years.

The Chairman then proposed a vote of thanks to Mr. Pope, which was carried unanimously, and the proceedings terminated.

ADDITIONAL LECTURES.

ON THE PRESERVATION OF ANIMAL STRUCTURES FROM DECOMPOSITION.

By Benjamin W. Richardson, M.D., F.R.S.

Lecture I.—Delivered Monday, February 3rd, 1879.

The object of these lectures was to demonstrate, from fifty-five specimens of dead animal structure, some further results of experimental research in the art of preservation. The lectures were, therefore, supplementary to and in continuance of the Cantor Course on "Putrefactive Changes," delivered by Dr. Richardson last year before the Society.

The specimens on the table on the present occasion had been under attempts at preservation for a period of seventy days. The intention was not simply to preserve them from putrefaction, which could easily be done by salting or cooking in vacuo, but to hold them in the fresh state, in respect to colour, firmness, and freshness altogether—as they were, in fact, at the time when they were submitted to experiment. The tests to which the specimens had been submitted were severe. Twenty-six had been kept at home under the most varying changes of temperature. Twenty-eight had been a tropical voyage, and had returned to England.

The methods for preservation that had been adopted had been deduced from the author's previous researches already published in the *Journal*, and from some that had subsequently been made. In the last course of lectures a great number of specimens were brought forward, and of them, those which promised well were exposed to the heat of all last summer, and were closely observed. Four of these specimens, still in excellent preservation, were again brought under notice. These had been preserved for nine months, and two of them retained all their original freshness of appearance and character.

Dr. Richardson next proceeded to give an

epitome of the results of his last course of lectures. He enumerated (*a*) the requirements of a true preservative, and the proofs of a perfect preservation; (*b*) the theory he has arrived at as to the cause of decomposition of organic animal matter, viz., that it is from the decomposition of the water in the tissues; (*c*) the mode of action of all preserving processes, by removal of water, by fixing of water, or by prevention of decomposition of water from the presence of bodies which, by their presence, prevent the decomposition of the water into its elementary parts, with fixation of the oxygen and liberation of the hydrogen.

The lecturer proceeded, after this *résumé*, to describe the mode of preparation of the fifty-five specimens then before the meeting. The specimens were all in glass jars, and coal gas had been used as the menstruum for the preservative gases and vapours that had been employed, and for the preservation of the colour of the coloured specimens, the carbonic oxide in the coal gas being the agent for the latter purpose. The modes of preservation were ranged in eight series, called respectively—

1. The Methylene series.
2. The Methylal series.
3. The Cyanogen series.
4. The Sulphurous Acid series.
5. The Sulphurous Acid and Lime-juice series.
6. The Sulphurous Acid and Glucose series.
7. The Formate of Soda series.
8. The Nitrate of Methyl series.

Four specimens of meats were used in the first six series, viz., beef, mutton, plover, and fowl, and two specimens of beef and mutton in the seventh and eighth series.

The mode of charging the bottles or jars with the specimens, and with the preservatives, and the proportion of preservative in each specimen having been described, Dr. Richardson explained that after their preservation on the 26th and 27th of November last, the specimens, in duplicate, were placed in two wooden cases, one set being for retention and observation at home, the other for transmission abroad on a return test voyage. The specimens kept at home were simply packed in straw in their case, the stoppers of the glass jars holding the specimens being tied down, but not sealed. They were placed in a room, the temperature of which varied, the variation of temperature within the case itself being recorded by self-regulating maximum and minimum thermometer, arranged for the purpose by M. Pillischer, of Old Bond-street. For the first six weeks, the temperature had been 74° Fahr. within the case during the day, and 35° Fahr. during the night. For the last four weeks the temperature had been kept more equably, viz., at 64° Fahr. during the day, and 54° Fahr. during the night. The extreme changes of temperature had been made during the first six weeks, because the author had observed in his previous experiments that such changes were more conducive to decomposition than a steady and rather high temperature, and he wished to make the test on the present occasion as severe as was possible, consistently with practical conditions under ordinary circumstances. The specimens which had been sent abroad were placed in a wooden case, of the same kind as that retained at home, but the case was lined with Baatsch's slag felt, in a thin zinc framework, and the glass jars were capped in straw, as wine bottles are. Specimens of the slag felt were exhibited, and its qualities were described. It is deemed to be a first-class non-conductor of heat. The specimens were placed at first in the temperature of 45° Fahr., and a self-registering maximum and minimum thermometer was placed with them to record the range of temperature. The bottles containing these specimens were tied down, and were also sealed down with sealing wax varnish. The case containing these specimens was, through the kindness of Messrs. Scrutton and Co., sent out to the West Indies and brought back to England on board the *Blenheim* steamer. The case was housed in the deck-house, and was thus left fully exposed to the heat of the voyage. It left England on December 2nd, 1878, and returned on January 27th, 1879.

Dr. Richardson next described the general results of the experiments in both instances, first in regard to the specimens of case number one, which had been kept at home, and secondly, in regard to those in case number two, which had been to the West Indies. In each case the same methods had been pursued in respect to the series of specimens and modes of preservation, with the exception that, in the voyage case, two extra specimens, one of beef and one of mutton, had been sent out with nitrate of methyl as a preservative. The comparison, therefore, between specimens kept at home and specimens which had been submitted to a voyage, could now be correctly seen. In the present lecture the examination of the specimens were made as the specimens appeared in their jars without removing them, the results were as follows:—

Specimens in case number one, retained at home for seventy days at temperature varying from 34° Fahr. to 74°, and 54° to 64°.

The four specimens in the first, or methylene series—methylene bichloride with coal gas being the preservative—were all perfect. They retained their colour as completely as when they were first put in the jar, and they were also of natural firmness. The jars were intact and the stoppers unloosed.

The four specimens in the cyanogen series were less favourable. The beef was rather dark. The mutton was natural, the plover natural, the fowl rather dark. In these specimens the quantity of cyanogen, which had been reduced to the smallest possible degree for preservation, was insufficient to preserve completely.

In the specimens preserved with methylal, the beef was slightly darker than natural, but otherwise good; the mutton was perfect in appearance, and the plover equally perfect. By an accident, the jar containing the fowl was cracked, and admitted escape of the contained gases. The fowl had consequently undergone decomposition.

The four specimens treated with sulphurous acid were of natural firmness, but the beef and mutton were rather darker than natural in colour, The other specimens retained their natural colour. All had yielded liquid from their structure.

The four specimens treated with sulphurous acid and lime juice were darker than natural, and

the mutton and fowl had on them points of decomposition. They had yielded fluid from their structure.

The four specimens treated with sulphurous acid and glucose were darker than natural, firm, and yielded fluid. The two specimens prepared with formate of soda, in proportion of two and a-half per cent., had been, after twelve hours exposure to coal gas, and treatment with the formate, surrounded in their bottles with suet fat. They presented an appearance entirely natural. It thus appeared that out of the twenty-six specimens, nine retained all their natural qualities of colour and firmness. The rest presented some variation from the natural. One specimen only, that, namely, which had been removed from its preservative, owing to the breaking of the jar, presented evidence of actual decomposition.

MISCELLANEOUS.

PUBLIC ELEMENTARY EDUCATION.

Subjects of the Code enumerated.

Elementary education, as defined in the Code, has a close connection with technical instruction, and what the Code calls "Domestic Economy." It has been suggested that it would be useful in the future considerations of technical instruction, and for the Congresses on "Domestic Economy," to have a list of the subjects of the Code in the *Journal* for reference. The subjects of instruction are stated exactly in the order, and the number of times is given in which they are named in the Code for 1878, with their references.

Subjects.—Seventy Subjects, including Repetitions.

I. Needlework.—17 f.—III. Sched., p. 28. (See also Plain Needlework, 19 C. I & 2.)

II. Singing.—19 A.

A.—*Discipline.*

*Punctuality.—19 A.

*Good manners and languages.—19 A.

*Cleanliness.—19 A.

*Neatness.—19 A.

*Obedience to duty.—19 A.

*Respect to others.—19 A.

*Honour and truthfulness.—19 A.

B.—*Compulsory Instruction.*

III. Reading.—19 B. 2.—28 I. to VI.—3 First Sched.

IV. Writing.—19 B. 2.—28 I. to VI.

V. Arithmetic.—19 B. 2.—28 I. to VI.—5 First Sched.

VI. Grammar.—19 C. I.—28 II. to VI.—4 First Sched.

VII. History.—19 C. I.—28 II. to VI.—7 First Sched.

VIII. Elementary Geography.—19 C. 1.—28 II. to VI.

IX. Plain Needlework.—19 C. 1.

X. Needlework again, for 3rd time.—19 C. 2.

XI. Welsh Language.—19 C 3.

XII. Domestic Economy.—21 f.—Sched. IV., col. 10.

XIII. Military Drill.—24.

XIV. Practical Cooking.—24.

XV. Weights and Measures.—28.

XVI. Sewing.—32 C. 3.

XVII. Health.—1 First Sched.—IV. Sched., 10 p. 30.

XVIII. Character and Conduct.—2 First Sched., 2.

XIX. Reading and Repitition.—3 First Sched., 3.

XX. English Grammar and Composition.—4 First Sched., 4.

XXI. Arithmetic and Mathematics.— 5 First Sched., 5.—IV. Sched., 2.

XXII. Geography.—First Sched., 6.

XXIII. History.—First Sched., 7.

XXIV. Teacaing.—First Sched., 8.

C.—*Additional Subjects.*

XXV. Latin—IV. Sched., 3.

XXVI. Greek.

XXVII. French.—First Sched., 9.—IV. Sched., 4.

XXVIII. German.—IV. Sched., 5.

D.—*Science Subjects and other Subjects.*

XXIX. Mechanics (A).

XXX. Chemistry (A).

XXXI. Animal Physiology (A).

XXXII. Acoustics, Light and Heat (A).

XXXIII. Magnetism and Electricity(A).

XXXIV. Physiology (A).

XXXV. Botany (A).

XXXVI. Drawing (A).—First Sched., 10.

XXXVII. Music.—First Sched., 11.

XXXVIII. English Literature.—IV. Sched., 1 p. 30.

XXXIX. Needlework named for 4th time.—3rd Sched.

XL. Mathematics.—IV. Sched, 2.

XLI. Latin.—IV. Sched., 3.

XLII. French.—IV. Sched., 4.

XLIII. German.—IV. Sched., 5.

XLIV. Mechanics (A).—IV. Sched., 6.

XLV. Animal Physiology (A).—IV. Sched., 7.

XLVI. Physical Geography (A).—IV. Sched., 8.

XLVII. Botany (A).—IV. Sched., 9.

E.—*Domestic Economy Subjects.*

XLVIII. Domestic Economy for Girls. — IV. Sched., 10.

XLIX. †Food and its Preparation.

L. †Clothing and Materials.

LI. ‡Dwelling.

LII. ‡Warming, Cleaning, and Ventilation.

LIII. ‡Washing Materials and their Use.

LIV. §Health.

LV. §Sick-room.

LVI. §Cottage Income and Expenditure.

LVII. §Savings.

Note.—The subjects marked (A) are thought to have a bearing on technical instruction; and so do many classed under Domestic Economy. Many of them are encouraged by the Science and Art Department. In another number it is proposed to give an alphabetical list for facility of reference.

* Discipline and organisation.
† 1st Stage. ‡ 2d Stage. § 3rd Stage.

CORRESPONDENCE.

THE PLAGUE.

There still appears to be an extensive persistence on the Continent in quarantine, as a defence against the spread of the epidemic disease which is designated by the old name of the plague, and which may be that disease in a new type. As such quarantines fail of real effect, and are at the same time grievously obstructive to commerce and intercommunication, I beg leave to state that both that disease and the accustomed defences were the subject of a close examination by our first General Board of Health in 1849. We did not rely upon book knowledge, or upon the opinions of our own medical staff, or upon those of the most eminent physicians of that time, who had never seen the disease; but we carefully collected the testimony of all whom we could find who had seen it and treated it in its latest visitations in the Levant and elsewhere; we also collected the testimony of officers of experience in the working of quarantine. Our conclusions, chiefly on the practical testimony so collected, were found to be in accordance with those of the medical authorities of France, and were accepted as authoritative on the Continent. Our report was translated and circulated, both in French and Italian. Our main conclusions were stated in the following terms:—

"Having carefully examined what appeared to be the best available evidence as to the facts on which the system of quarantine rests, having considered the Report made to the Royal Academy of Medicine in France, and the written testimony of the most eminent professional and scientific observers and writers, as well in Austria and America as in England, we have now to report as our conclusions,—

"That the chief pestilence in respect to which quarantine establishments have been kept up in this country, the Oriental plague, is, in its antecedent circumstances or causes, in the localities, classes, and conditions of the population attacked, and in its rise and progress, a disease of the same essential character as typhus, being, according to the most recent authorities who have had practical experience of the malady, a form of that disease modified and rendered more intense by peculiarities of climate and of social condition.

"That the notion of the propagation of the plague by means of goods appears from one uniform mass of evidence to be as entirely unfounded as the opinion which formerly prevailed in this country that typhus could be propagated in the same mode.

"That the true danger of the propagation of plague is not by contact of the affected with the healthy, but by exposure on the part of susceptible subjects to an infected atmosphere, under the like conditions which are known to produce and propagate typhus fever in this country.

"That the quarantine establishments in this country, and every other of which we have information, are wholly insufficient, even on the assumption on which they have wholly hitherto been maintained, to prevent the introduction and spread of epidemic disease.

"That these establishments are of a character to inflict on passengers extreme and unnecessary inconvenience, and to subject such of them as may be sick to increased suffering and danger, while they maintain false securities in relation to the means of preventing the spread of disease.

"That typhus and other dangerous epidemic diseases are frequent on board merchant-seamen vessels at sea and in port, for which no effectual or suitable provision is at present made.

"That as far as relates to the cases of epidemic diseases generated at sea, the principle of the concentrating of responsibility on the shippers, in making it their pecuniary interest to complete the voyage with healthy passengers, operates most effectually in the cases where it has been applied, such as to emigrant, transport, and convict ships, and should be extended in all cases; and that in respect to ships in port, the regulations applied to the prevention of the spread of epidemic diseases from houses in towns are applicable, and would practically be highly beneficial.

"That the substitution of general sanitary regulations to ships in port, for the existing quarantine regulations, would far more effectually extinguish epidemic disease, and afford better protection to the uninfected on ship-board, whilst it would relieve passengers and crews from grievous inconvenience, abate the motives to concealment of sickness and to false representations as to its nature, greatly lessen commercial expenses, and remove obstructions to the free transit of goods and uninfected persons which the existing system of quarantine occasions.

"It follows that we propose the entire discontinuance of the existing quarantine establishments in this country, and the substitution of sanitary regulations.

"By such substitution the most effectual security which the present state of knowledge affords would be taken against the importation of foreign contagion, the maintenance of infection, and the origin and spread of epidemic disease.

"The British Parliament has legislated on the conclusion, submitted with an accumulation of demonstrable evidence, that the causes of epidemic, endemic, and contagious disease are removable, and that the neglect on the part of the constituted authorities to remove such causes, as far as they are obviously within their control, is a punishable offence. The foundation which the Legislature has thus laid for the physical, and consequently for the moral, improvement of the people is recognised. Half a century ago it was said by a great physician and philanthropist......that the time would come when the Legislature would punish communities for neglecting the known means of preserving the public health, and that prediction the British Parliament has been the first to realise.

"'To all natural evil,' says Dr. Rush, 'the Author of Nature has kindly prepared an antidote. Pestilential fevers furnish no exception to this remark. The means of preventing them are as much under the power of human reason and industry as the means of preventing the evils of lightning and common fire. I am so satisfied of the truth of this opinion that I look for the time when our courts of law shall punish cities and villages for permitting any of the sources of malignant fevers to exist within their jurisdiction.'"

Being charged with authority to deal with extraordinary epidemic visitations, we exercised it, as set forth in the following terms of our report:—

"The substitution of the sanitary regulations which we propose for the existing system of quarantine, though the expense that may fall on these particular ships which, through neglect or mismanagement, continue to have outbreaks of epidemic disease, were much larger than we contemplate as possible, must effect a large ultimate economy even of money; while it would at once put an end to those grievous inconveniences and anxieties to which the public are at present subjected, we think, unnecessarily, and without any compensating advantages.

"Instead of detaining all vessels whatsoever arriving from ports which may happen to be the seats of epidemic disease, we propose to detain only the persons who may be in an actual state of ill-health, or labouring under epidemic disease. Instead of keeping the parties infected together on board their own vessel, or in a building of the description of those used as lazarets, we propose that they shall, as far as practicable, be

immediately separated, and removed to places where the air is pure, and where suitable accommodation may be provided for them. Instead of arresting vessels which arrive at a port distant from a quarantine station, and keeping passengers together who may be in a state of disease until they are sent to a distant quarantine station, we propose that medical attention shall be given at once on the spot, and for their own proper relief in the first instance, and not as sacrifices to the false notion of security to persons on shore.

"Instead of restricting authoritative care to certain epidemics from distant countries, and omitting attention to all others, we propose that immediate attention and relief should be provided for all cases of epidemic disease whatsoever, as well to those which may be contracted in port as to those which are brought into it.

"Instead of detaining cargoes, we propose their immediate discharge (cargoes in a state of putrescence only excepted), universal experience, as has been fully shown, without the exception of any place in any season or country, having exhibited no one case, or even the allegation of one, where the persons employed in opening packages of goods at quarantine stations have ever been attacked with plague, yellow fever, or cholera, or any other supposed contagious disease therefrom."

Some reactionary opinions in support of quarantines and quarantine establishments were afterwards enunciated, but it will be found that these opinions have been negatived, and our first conclusions have been reaffirmed by experience on a large scale in India, as may be seen in the reports of the Army Sanitary Commissioners. It has, indeed, been announced that the pestilence in question has at places "broken through the most rigid quarantines established by the Russian Government." It may be pointed out, as an important topic of observation, by those sent to examine the conditions and progress of the pestilence, whether it is preceded by such premonitory symptoms as were found in the instance of the cholera epidemics, and as were informed in respect also to visitations of the yellow fever; and the Russian medical officers may be reminded that when our instructions in that respect, and in respect to sanitary measures, were acted upon, on the occasion of the last visitation of the cholera at St. Petersburgh, as stated by Professor Zdekaeur, at our last Sanitary Congress at Brussels, the death-rates were reduced to a quarter of those visitations which had preceded it.

In conclusion, I would like to draw the special attention of the Chambers of Commerce at the various English ports to the above considerations.

EDWIN CHADWICK.

GAS ILLUMINATION.

In consequence of press of business, the letter of your correspondent, Mr. G. Bray, in the *Journal* of 21st inst., was overlooked until my attention was particularly drawn to it. As the statements made therein are calculated to mislead those of your readers who are not acquainted with the facts relating to improvements in gas lighting, permit me to furnish the following particulars:—

During the discussion after Dr. Wallace's paper, I incidentally stated that I was the inventor of the "Hollow Top Steatite Burner"—a burner which is shown to give very excellent results in Dr. Wallace's reports. The date of the production of my original model was about Christmas, 1867. It was made in my workshop, and the workman who made it is still in my employ. It was my intention to have patented it in this country, but I was prevented from doing so. At that time, steatite articles were not manufactured in England for want of the suitable steatite. I therefore sent my model over to Germany, as I had been in the habit of doing, to a manufacturer to make it for me in steatite. He had been for years in business relations with me, and had made from my models my first Argand tops and my street-lamp and other burners in steatite. On this occasion, however, he thought proper to make and sell these burners in several parts of Germany before sending me any of them. My friend and correspondent, Herr Christopher Friedleben, one of the most eminent German gas engineers (well-known in England), sent me some of the first samples of my hollow-top steatite burners, with the remark that they were the finest flat-flame burners he had ever seen. Thus, having been published in Germany without my knowledge or consent they could not, I was advised, be patented in England. Of course my business relations with the German manufacturer were immediately closed.

The burners mentioned by your correspondent as being patented in 1860 are metal burners. I observe that the patentees specially claim the idea of hollowing the top of the solid burner. There the resemblance to my burner ends, for metal burners of any kind do not give so good results as the steatite burners. Mr. Justice Quain, sitting in banco with the Lord Chief Justice and Mr. Justice Mellor, asked the following question relative to a gas burner which, he was assured, was similar to, and in fact an anticipation of, the "London" Argand burner. "Does it give results equal to the 'London' burner?" The answer was, "No." "Then," said he, "If it is the same thing, why does it not?" For the same reason, I say that the burner mentioned by your correspondent is not the same thing as my hollow-top steatite burner.

It is also fair to assume that your correspondent himself is perfectly convinced that Wadsworth's metal burner does not give so good a result as my steatite hollow-top, or he would not have patented, as he says he has, the hollow-top burner manufactured in the material he calls "enamel," which, if his patent is to hold good, must produce better results than either. On applying for his patent, he made a solemn declaration that he is the true and original inventor of the hollow-top burner —made in enamel—and he holds the patent granted him on the condition that the results to be obtained from the burner thus made shall be superior to those obtained from either Wadsworth's metal or my steatite hollow-top burners. Failing this he has no patent. From the foregoing it is clear that the fear which your correspondent expressed, lest the honour of inventing the hollow-top steatite burner should be misplaced, is entirely groundless. As to the relative merits of steatite and enamel, any of your readers can easily set this point at rest by making a trial of both.

Having disposed of the main question, I may now say that until yesterday I had never seen the patent of 1860 mentioned by your correspondent. I am tolerably certain also that the burner shown in their specification was never published by the patentees. They say that the hollowing of the head is done by a tool made expressly for the purpose, but not in any way described. This operation, though quite easy in such a material as steatite, which in the unburnt state is as soft as ivory, is very difficult to carry out commercially in brass or iron, and as the patent is principally for the manufacture of gas burners out of sheet brass by the process of "stamping," "knurling," or "milling"—all of which are much easier operations—it is more than likely that the solid burner was only included in their specification to prevent any unscrupulous person from jeopardising their patent, by making the improved hollow-top burner in solid instead of sheet metal. The millions, which your correspondent says, have been made must, I think, be of the latter class. I have never met with any specimens of the former.

Your correspondent also finds fault with my statement, rather loosely expressed, it must be confessed, in your report (which I see is not verbatim), "that the Sugg-Letheby burner was the first step in the direction of consuming gas at low pressure." I believe I said "properly consuming gas at low pressure." I meant to

have said so if I did not. The prototype of the "Sugg-Letheby" burner, differing only from the latter in the dimensions of the central aperture, was proposed as a standard burner by Mr. George Lowe before a Committee of the House of Commons in 1858, but did not become a standard until 1863, when it was adopted by Dr. Letheby for testing the gas supplied to the City of London, and it became known as the "Sugg-Letheby" burner. This burner was considered at that time by the most eminent engineers, such as Messrs. George Lowe, F. J. Evans, T. N. Kirkham, and other authorities, including the late Dr. Letheby, as the first step in the development of the proper illuminating power of gas.

Having now taken up so much of your valuable space in stating these facts, permit me to remark that the authoritative statement of your correspondent, that "we have no steatite burners made in England," is erroneous in any other sense than as applying to his own firm. If by "we" he means the people of England he is wrong, for there is at the present moment a large quantity of steatite burners in use which have been made entirely at my works in Westminster, and are generally considered to be excellent. Among the steatite burners thus made are those now in Waterloo-road, Lambeth; Waterloo-place, Regent-street; and Queen Victoria-street, City; and also the two large burners which attracted so much attention at the Society of Arts on the evening of Dr. Wallace's paper.

In conclusion, I should like to be permitted to ask your correspondent three questions:—1st. What is the difference, if any, between "Leoni's adamas" and "Bray's enamel"? 2nd. Why he thinks the "hollow-top" burner ought to have its name changed to the "slit-union"? Lastly, whether he has found the "enamel" burners give better results in illuminating power than either steatite or adamas?

A reply to these questions will, I am sure, be acceptable to your readers, as well as to those who, like myself, were deprived of the pleasure of his company on the evening of the paper.

WILLIAM SUGG.

Vincent Works, Westminster,
February 27th, 1879.

GENERAL NOTES.

Trade-marks.—The Office for the Registration of Trade-marks has recently issued a statement of the number of trade-marks advertised, and of the number registered in each of the 50 classes of goods respectively, from 1st January, 1876, to 31st December, 1878. The total numbers for each year are as follows:—1876—Advertised, 4,874; registered 454. 1877—Advertised, 7,907; registered, 8,753. 1878—Advertised—3,240, registered, 3,687. Total for the three years—Advertised, 16,021; registered, 12,894.

Exhibition of Cutlery.—The London Company of Cutlers announce an exhibition of cutlery in its various branches, including surgical and sword cutlery, to be held at the Cutlers'-hall, from the 1st to the 8th of May. The competition will be divided into three sections, viz., 1, cutlery in its various branches; 2, surgical cutlery; 3, sword cutlery in its various branches. Competitors must be workmen or apprentices engaged in the cutlery trade. They will be permitted to show their work in its various stages, and, if required, they must produce satisfactory evidence that the work exhibited has been performed by them. Tools and implements used in the manufacture of cutlery may also be exhibited. One prize will be given in each of the divisions. This will consist of an illuminated certificate of merit, and in addition to this the company will place at the disposal of the judges a sum of £100 to be awarded, in such sums as they think proper, amongst such of the competitors as may gain certificates of merit.

Hall-Marking.—Parliamentary returns have been issued of the sums received at the goldsmiths' halls at London, Birmingham, Chester, Dublin, Edinburgh, Newcastle, Sheffield, and Exeter, for duty and hall-marking in each year from 1867 to 1877 inclusive, showing also what moneys were paid into the Treasury out of the receipts during each year, what the amount of working expenses, and what was the appropriation of the surplus fund, if any. The returns show also the weight of gold and silver respectively that was hall-marked in each of the above years at each of the halls beforenamed. In London the duty on marking amounted to £535,182, of which the Commissioners of Inland Revenue received £452,601. The total weight of metal marked was—gold, 70,317 lb., and silver, 830,171 lb. The receipts during the same period were £77,273, and the disbursements, £74,157. The surplus was carried to an accumulation fund. In Birmingham the sum received for duty amounted to £171,989; 967,451 ounces of gold wares and 1,355,258 ounces of silver wares were assayed and marked, and £37,464 was received for hall-marking.

Indian Botanic Gardens.—The Indian Government *Gazette* contains papers on the proposed Presidency Botanic Gardens, including a Government minute and the report of the committee. The committee's consideration was invited to the question whether Puna or Bombay should be chosen as the place for the principal botanic garden of the Presidency. They decided in favour of Ganesh Khind. They recommend, however, that a small branch garden, consisting of four or five acres, be established in Bombay, and that the Grant College compound be selected for the purpose. The Government highly approved of all the recommendations, which will be carried out whenever financial means may permit. The main scientific garden, which will embrace about forty acres, is to be laid out in the irregular picturesque style, with special reference to landscape effect, and the planting of the ground will be done gradually and without any undue haste. It may be mentioned here that the chief resources of the garden are to be devoted to the bringing together of the indigenous plants of Western India, and until this is satisfactorily accomplished no pains will be taken, except in special cases, to introduce foreign plants. An extraordinary expenditure of Rs. 22,037 will have to be incurred for the purpose of constructing roads and footpaths, excavating a ground, erecting houses and sheds, providing iron piping, &c., for water supply, fitting up rooms for the herbarium, library, and class-room, and for the purchase of botanical books and diagrams. The estimated annual expenditure is, in round numbers, Rs. 12,000.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at Eight o'clock:—

MARCH 12.—"The Compensation of Watches, Clocks, and Chronometers." By EDWARD RIGG, Esq., M.A.

MARCH 19.—"Economical Gardens for Londoners." By W. MATTIEU WILLIAMS, Esq., F.R.A.S., F.C.S.

MARCH 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor BARFF, M.A. F. A. ABEL, Esq., C.B., F.R.S., will preside.

APRIL 23.—"English Fresh-water Fisheries." By J. WILLIS-BUND, Esq., Chairman of the Severn Fishery Board.

APRIL 30.—Renewed Discussion on Mr. John Holloway's paper (read February 12) on "A New Process in Metallurgy." Prof. H. E. ROSCOE, F.R.S., will preside.

AFRICAN SECTION.

Tuesday Evenings, at Eight o'clock.

MARCH 18.—"Africa, a Paramount Necessity for the Future Prosperity of the Leading Industries of

England." By James Bradshaw, Esq., of Manchester. Sir T. Fowell Buxton, Bart., will preside.

After the reading of Mr. Bradshaw's paper there will be a general discussion on the various schemes that have been proposed for the introduction of trade and civilisation into the interior of Africa.

April 1.—1. "Some Remarks upon an Old Map of Africa contained in Janson's Atlas, published at Paris in 1612." Communicated and exhibited by R. Ward, Esq.; and, 2. "The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

April 29.—1. "Light Railways for Opening-up a Trade with Central Africa," by John B. Fell, Esq.; and, 2. "The Advantage of Railway Communication in Africa, as compared with any other Mode of Transport," by J. Conyers Morrell, Esq.

Chemical Section.

Thursday Evenings, at Eight o'clock.

March 13.—"The Injurious Effects of the Air of Large Towns on Animal and Vegetable Life, and on Methods Proposed for Securing Salubrious Air." By W. Thomson, Esq., F.R.S.E.

Indian Section.

Friday Evenings, at Eight o'clock.

March 7.—"The Plants of India adapted for Commercial Purposes." By John R. Jackson, Esq., Kew Museum. Dr. Forbes Watson will preside.

Cantor Lectures.

The Second Course is by Dr. W. H. Corfield, M.A., on "Dwelling-houses: their Sanitary Construction and Arrangements."

Lecture IV.—March 10.

Removal of Refuse Matters.—Dust, kitchen refuse, earth-closets, &c. Conservancy and water-carriage systems compared.

Lecture V.—March 17.

Sewerage.—Main sewers and house branches, traps, ventilation, &c.

Lecture VI.—March 24.

Water-closets, Sinks, and Baths.—Arrangements of pipes, traps, &c.

N.B.—The Course will be illustrated by specimens and models from the Parkes Museum of Hygiene.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. W. H. Corfield, "Dwelling Houses; their Sanitary Construction and Arrangements." (Lecture IV.)
Royal Geographical, University of London, Burlington-garden, W., 8½ p.m. Dr. James Stewart, "The Second Circumnavigation of Lake Nyassa."
British Architects, 9, Conduit-street, W., 8 p.m. Special General Meeting.
Medical, 11, Chandos-street, W., 8.30 p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. H. A. Severn, "The Theory of Combustion, and History of Artificial Illumination."
Law Amendment Society, 1, Adam-street, Adelphi, W.C., 8 p.m. Adjourned Discussion on Mr. Henry Kimber's paper, "Bankruptcy Law and its Administration."

Tues....Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture IX.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. James Price, "Movable Bridges."
Photographic, 5a, Pall-mall East, S.W., 8 p.m.
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Mr. E. Burnett Tylor, "The Geographical Distribution of Games." 2. Mr. Hector Maclean, "Gaelic Mythology."
Royal Horticultural, South Kensington, S.W., 1 p.m.

Wed.... **SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. Edward Rigg, "The Compensation of Watches, Clocks, and Barometers."
Geological, Burlington-house, W., 8 p.m. 1. Mr. G. Jennings Hinde, "Conodonts from the Chazy and Cincinnati Groups of the Cambro-Silurian, and from the Hamilton and Genesee Shale Divisions of the Devonian, in Canada and the United States." 2. Mr. G. Jennings Hinde, "Annelid Jaws from the Cambro-Silurian, Silurian, and Devonian Formations in Canada, and from the Lower Carboniferous in Scotland." 3. Mr. H. S. Poole, "The Gold-leads of Nova Scotia." 4. Mr. Frank Rutley, "Perlitic and Sphærulitic Structures in the Lavas of the Glyder Fawr, North Wales."
Graphic, University College, W.C., 8 p.m.
Microscopical, King's College, W.C., 8 p.m. 1. Mr. A. D. Michael, "A Contribution to the Knowledge of British *Orchatidæ*." 2. Mr. George Hoggan, "The Development of the Fat Cell."
Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m. Annual Meeting.
Royal College of Physicians, Pall-mall East, S.W., 5 p.m. (Gulstonian Lectures.) Dr. Curnow, "The Lymphatic System and its Diseases." (Lecture II.)
Society of Telegraph Engineers, 25, Great George-street, Westminster, S.W. 1. Adjourned Discussion on Mr. Willoughby Smith's Paper on "The Working of Long Submarine Cables," and Mr. James Graves's Paper on "Curbed Signals for Long Cables." 2. Professor D. E. Hughes, "Experimental Researches into Means of Preventing Induction upon Lateral Wires."

Thur....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Chemical Section.) Mr. W. E. Thomson, "The Injurious Effects of the Air of large Towns on Animal and Vegetable Life, and on Methods Proposed for securing Salubrious Air."
Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 7 p.m. Mr. Ernst Pauer, "English Composers for the Virginal and Harpsichord."
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Tyndall, "Sound." (Lecture V.)
Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.
Royal Historical, 11, Chandos-street, W., 8 p.m. 1. Col. the Hon. J. B. Finlay, "John Calvin." 2. Rev. Charles Rogers, "Remarks on the Study of History, with Special Relation to Scotland."
Royal Society Club, Willis's-rooms, St. James's, S.W., 6 p.m.
Mathematical, 22, Albemarle-street, W., 8 p.m. 1. Sir J. Cockle, "Differential Equations, Total and Partial, and a New Soluble Class of the First and an Exceptional Case of the Second." 2. Mr. J. D. H. Dickson, "Discussion of Two Double Series Arising from the Number of Terms in Determinants of Certain Forms." 3. Prof. H. J. S. Smith, "Property of the Discriminant of the Cubic."

Fri.......Royal College of Physicians. Pall-mall East, S.W., 5 p.m. (Gulstonian Lectures.) Dr. Curnow, "The Lymphatic System and its Diseases." (Lecture III.)
Royal United Service Institution, Whitehall-yard, 3 p.m. Lieut.-Col. C. B. Brackenbury, "Military Transport."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m., Mr. E. B. Tylor, "The History of Games."
Astronomical, Burlington-house, W., 8 p.m.
Quekett Microscopical Club, University College, W.C., 8 p.m.
Clinical, 53, Berners-street, W., 8½ p.m.
New Shakespeare Society, University College, W.C., 8 p.m. Rev. M. Wynell Mayow, "Which is the Next Greatest of Shakespeare's Plays after 'Hamlet'?"

Sat......Royal Institution, Albemarle-street, W., 3 p.m. Mr. Walter H. Pollock, "Colbert and Richelieu." (Lecture II.)

Erratum.—In report of Cantor Lecture, on page 166 of *Journal* for January 31, the eighth line from the bottom of second column should be transposed to make the sixth line from the bottom.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,373. Vol. XXVII.

FRIDAY, MARCH 14, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference will be held in the Rooms of the Society of Arts, on Thursday and Friday, the 15th and 16th May, 1879, on National Water Supply, Sewage, and Health, the Right Hon. James Stansfeld, M.P., late President of the Local Government Board, in the chair, assisted by the members of the Executive Committee :—Lord Alfred Churchill (Chairman of Council); Sir Henry Cole, K.C.B.; Colonel Sir E. Du Cane, K.C.B.; Captain Douglas Galton, C.B., F.R.S.; Mr. F. A. Abel, C.B., F.R.S.; Mr. T. W. Keates; Dr. Voelcker, F.R.S.; Mr. W. Hawes, F.G.S.; Major-Gen. F. Cotton, R.E., C.S.I. Papers relating to the above subjects will be read and discussed.

Programme of Proceedings.

The Conference will meet each day at 11 a.m., and sit till 1.30, then adjourn till 2, and sit again till 5 p.m., and, if necessary, meet again at 8 p.m.

Thursday, 11 a.m.—Opening of the Proceedings by the Chairman.
Papers and Discussion.
Friday, 11 p.m.—Proceedings will be resumed.
Papers and Discussions continued.

There will be an Exhibition of Mechanical and Chemical Apparatus in connexion with Water Supply, Treatment of Sewage, and Health. All articles for exhibition must be delivered, carriage free, not later than Saturday, the 10th May, 1879. Manufacturers and others desiring to exhibit should communicate forthwith with the Secretary of the Society of Arts.

Papers on any of above heads are requested.

The object of the Conference is to discuss existing information in connexion with the results of any systems already adopted in various localities, referring to the subjects of National Water Supply, Sewage, and Health; to elicit further information thereon; and gather and publish, for the benefit of the public generally, the experience gained. The introduction and discussion of untried schemes will, therefore, not be permitted. The papers accepted for the Conference will be printed and circulated at the Meetings.

Prize Medals.

1. The Council of the Society of Arts offers one Gold and three Silver Medals for the best suggestions, founded upon evidence already published, for dividing England and Wales into districts, for the supply of pure water to the towns and villages in each district.

2. The districts should be laid out on a skeleton map scale, which can be obtained from Mr. Stanford, 55, Charing-cross, price 6d. each.

3. The average rainfall in the district should be stated; also the population of the district, and its geology.

4. The suggestions should be written on foolscap, half-margin, and sent, accompanied by maps, under cypher, to the Secretary of the Society of Arts, on or before the 26th day of April, 1879.

5. The maps will be exhibited, and the suggestions will be discussed at the Conference on National Water Supply.

6. The Council will invite the assistance of eminent authorities to recommend the competitors worthy to receive the prizes; but the prizes will be withheld if the suggestions made do not appear to the judges to be of sufficient merit.

INDIAN SECTION.

Friday, March 7th; Dr. J. Forbes Watson in the chair.

The paper read was—

INDIAN PLANTS ADAPTED FOR COMMERCIAL PURPOSES.

By John R. Jackson, A.L.S.

The recent adaptation in this country of many products and remedies furnished by Indian plants has directed fresh attention to our Eastern possessions, as a source from whence we may, in time, expect to receive many new and valuable commodities. Considering the vast extent of country, and the varieties of climate that prevail over the great Indian continent belonging to the British Crown, it is, perhaps, not a little surprising that more has not already been done to develop its resources. It is true that several noble efforts have been made to introduce and acclimatise foreign plants of acknowledged commercial value, and this extending over a number of years down to the present time; and some of these efforts have been eminently successful. It is not necessary for me to do more than merely refer to these introductions, by which you will understand me to allude primarily to the cinchonas, the

Para rubber plant, and the mahogany tree. There is, no doubt, a large field still open for successful culture in India of many valuable economic plants, not only those which, like the cinchonas themselves some years back, are in great danger of being exterminated from their native homes, but many also whose wider geographical range of culture would add to the world's resources, and, by competition, produce larger supplies, at consequently cheaper rates to the consumer; and besides this consideration for the consumer at home, the larger the area of land put under profitable cultivation the better it is for the country concerned, not only on the score of increasing its revenues, but, what is of equal importance, the employment of the population in tilling the soil, or in the various arts and manufactures which proceed from a system of high cultivation, and, as a result of all this, a contented and prosperous people. It will not be denied that these are points to be aimed at in the formation of any new country, and, though India cannot be said to be a new country, either historically or in its relation to England, we, unfortunately, are not in a position at the present time to say that that peace and prosperity, so desired by us all, reigns over the extent of our Eastern Empire. On the other hand, India still requires much careful consideration, not only from the diplomatist and the military tactician, but also from those skilled in the arts, manufactures, and commerce, on whose individual or united exertions much of its future prosperity depends.

It is not to the subject of the introduction or acclimatisation of foreign plants in India, of which I have incidentally spoken, that I wish to draw particular attention. There is plenty of room in the country for this kind of work to go on, and there are plenty of plants suitable for such introduction; but it must not be forgotten that India is specially rich in plants of acknowledged economic value, whether they be regarded as furnishing food, medicine, or clothing materials; but, over and above this, it possesses numberless plants, the value of which is not known out of their own country, or if known is not yet appreciated, and these consequently await a further development of their uses. Then again, going still further, we may say, we shall be disappointed, if absolutely new properties are not discovered in many plants as they become more known, and by their more extended application the money value of the vegetable products of India will go on increasing. Of the extent and variety of these products at present known a good idea may, of course, be had from the fine collection in the India Museum at South Kensington, or from a glance at the extensive series brought together at the Paris Exhibition last year. This most valuable collection, which included woods, fibres, gums, resins, drugs, &c., was got together by the officers of the Forest Department under Dr. Brandis, and, though the collection exhibited at Paris has found a resting place in the Forest School at Nancy, I am sure you will be glad to hear that a duplicate set has been sent to this country, and is now deposited in the museum at Kew. This collection is one essentially of forest produce, and, as such, exhibits the great importance of the Forest Department as it is managed in India; for besides the preservation and extension of valuable timber trees, which may be considered the legitimate work of forest conservancy, the production of gums, resins, and not a few drugs is necessarily associated with them. Were the work of the conservancy department confined to the preservation of trees for the sake of their timber alone, this would, indeed, be a good work, for we must not forget how rich India is in woods, valuable both for structural and cabinet purposes. Thus, for instance, next to our own European timber, oak, teak takes foremost rank, and is very widely known and used. The preservation, therefore, of the teak forests, of the saul, sandal, and other similar woods, is a matter of vital importance to the country, and it is satisfactory to know that this branch of Indian produce is now placed on such a sound and practical basis; and though there may be differences of opinion as to the means we have in England, or rather the lack of means, for the training of forest officers for India, we can but feel the necessity of a similar forest department in many other parts of the world. Included amongst forest produce, the bamboos hold a prominent place, whether we consider the endless uses to which they are put in India, or their more extended application to which so much attention has recently been drawn, namely, that for paper making. It would occupy far too much time, besides going over ground that has been traversed before, to give even the heads of the statements put forward in favour of the bamboo, or of those advanced against its practical and profitable utilisation. The opinions of Mr. Thomas Routledge on the one hand, and of Dr. King, superintendent of the Botanic-gardens, Calcutta, on the other, will no doubt be fresh in the memory of many members of the Society of Arts, having recently appeared in your own *Journal*. Those interested in the subject, I would advise to obtain a little pamphlet recently issued by Mr. Routledge, under the title of "Bamboo and its Treatment," as well as Mr. Routledge's first pamphlet, published in 1875 by E. and F. Spon, entitled "Bamboo considered as a Paper-making Material." Whether the trade in bamboo as a paper-making material will ever develop into an acknowledged branch of commerce remains to be proved; to say the least, it seems not at all improbable, and so satisfied on the subject is Mr. Routledge, whose opinion must be taken as having some weight, on account of his great practical experience, that he says in the preface to his most recent pamphlet:—"Desiring to fully ventilate the question generally of fibrous materials suitable for paper-making purposes, I have appended hereto other data bearing on this important subject which merit full consideration, not only from a practical but commercial point of view, especially in relation to our great Indian dependencies."

In considering the suitability of Indian plants for commercial purposes, I cannot hope to introduce to notice anything absolutely new. Indian botany has received the attention of some of the most prominent botanists the world has produced, notably Roxburgh, Wallich, Griffith, Wight, Hooker, and Thomson, and amongst those who have taken up Indian botany specially from a practical or economic point of view may be mentioned Royle,

our honoured chairman, Birdwood, M. C. Cooke, and a host of others. The foundation of botanic gardens, and the work that has been carried on in them, together with the formation of agricultural and horticultural societies in different parts of India, have all had their influence for good, by introducing new methods of cultivation, by offering prizes for essays on the cultivation of some well-known economic plants, or for the improvement by cultivation of indigenous fruits and other produce. It cannot be denied that the existence of these societies not only has given and still gives an impetus to cultivation, but spreads a knowledge of the uses of plants among their members, and an interest to further and develop those uses, or to find new applications. Regarding the introduction into, and the distribution from, India of new plants and seeds, which is to a certain extent carried on by the societies referred to, much of course is done by the Government gardens at Calcutta, Saharunpore, Madras, Ootakamund, and Bangalore. All these gardens are centres of botanical knowledge, and are superintended by well known and competent botanists. That the uses of botanic gardens are thoroughly understood and appreciated in India would seem to be proved from the fact, as we learn from a recent number of *Nature*, of its having been proposed to establish Presidency Botanic-gardens, and a committee chosen for considering whether Poona or Bombay should be selected as the place for the principal garden of that Presidency, the decision being in favour of Ganesh Khind. "They recommend, however," continues the paragraph above referred to, "that a small branch garden, consisting of four or five acres, be established in Bombay." "The Government," we are further told, "highly approved of all the recommendations, which will be carried out whenever financial means may permit." The main scientific garden, which will embrace about forty acres, is to be laid out in the irregular picturesque style, with special reference to landscape effect, and the planting of the ground will be done gradually and without any undue haste." The chief resources of the garden, it seems, are to be devoted to the bringing together of the indigenous plants of Western India, and, until this is satisfactorily accomplished, no pains will be taken, except in special cases, to introduce foreign plants. A herbarium, botanical library, and class rooms, furnished with diagrams, are to be attached to this garden. Having said so much about the value of botanical gardens, and agricultural and horticultural societies, in diffusing an interest in plants and their consequent utilisation, I will next briefly allude to what has been done in furtherance of the same object by the aid of books. Many gentlemen here present know as well or better than I do of the extent and value of this class of literature, and I need only mention the titles of a few, such as Royle's "Productive Resources of India," "Fibrous Plants of India," Drury's "Useful Plants of India," Birdwood's "Bombay Products," Balfour's "Timber Trees of India," and last, though not least, Brandis's "Forest Flora," to show that Indian products have received from time to time a great deal of careful attention; and, even down to our own day, I might further mention the labours of Dr. Cooke on the gums, resins, oleo resins, and oils, and those of Dr. Dymock on Indian drugs, which have been appearing periodically for the last two years or more in the *Pharmaceutical Journal*, to say nothing of the numerous papers to be found in the *Journal* of this Society. In view of all the illustrious names I have mentioned, besides many others that will occur to you who have quietly, perhaps for the most part with their pens and without any pomp of State, helped to make India what we see her at the present day—in view, I say, of all this, it does seem presumptuous on my part to come before you to ventilate a subject that would have been much better introduced by many gentlemen in this room, who have spent a portion of their lives in India, or who have made India's products their special study. Of the Indian plants that appear from descriptions of their uses already given, or from the uses to which they are known to be put in their native country, I can only enumerate a comparatively few, sufficient, however, for the purpose of illustrating that the resources of India, let alone those of the world at large, are far from being exhausted. New products in the vegetable kingdom undoubtedly there are yet to be discovered; indeed, scarcely a year passes but some novelty is brought to the knowledge of the authorities at Kew, as the director's annual reports show. Speaking generally, a very great deal more might be done than is done to bring new products into use, or to develop the applications of others of which we at present know but little. Hitherto it has, unfortunately, been the fashion to condemn without a lengthened and fair trial any new product that may have come into the market, unless it bears prominently on the face of it an indication of commercial success. Naturally, the first question is will it pay? and if at the first onset from various causes it appears as if it will not pay, it is cast on one side, perhaps to crop up again at some future time more or less remote. Notices may be written and descriptions given in the various journals of our day, but unless the new product has at first some very strong claims, or some competent and energetic champion comes forward to stand by it, it more frequently sinks into oblivion. No surer or better way to prevent this, and to make the resources of any country known, is to bring the matter before the ordinary or sectional meetings of this Society, where it can be freely discussed, both in its scientific and commercial bearings; and it is with this view that I wish to point out some economic products of Indian origin that have recently been introduced into this country, and have now become recognised articles of trade, in the hope that my simple statement of facts will act as an incentive to further research into the properties of Indian plants known to be used by the natives whether for food, medicine, or manufacture. At this point I cannot but refer to what has been recently done by Mr. Thomas Christy in bringing commercial plants to the light of day, since, by a thorough investigation of all products which appear to be really useful, and introducing them to the commercial world, several have become acknowledged articles of trade between India and this country. I will now direct your attention to a few of these commercial plants from India, the most important of which is undoubtedly the *Gynocardia odorata*, or chaulmugra tree. It

belongs to the natural order Bixaceæ, and is a large tree, native of Pegu, Tenasserim, and other parts of the Malayan peninsula, extending into Assam, Khasiá, and Sikkim. It does not, however, reach the central or western parts. The fruit is round, somewhat like a large orange, containing numerous irregularly ovoid seeds, and it is from these seeds that the oil is expressed: it has a faint unpleasant taste and smell, and, as found in the Indian bazaars, is usually very impure. Mr. Christy says, in a pamphlet recently issued by him that, "the pure oil in India is expensive, and therefore offers a great inducement to the natives to adulterate it; indeed, adulteration is carried to such an extent, and is so difficult to detect, that it has occasionally caused medical men in India to discontinue its use. In the Mauritius it is said that so high a value is put upon its purity that the seeds are imported from India for the purpose of obtaining the oil free from adulteration. Though this oil has been long used in India and China as a remedy for skin diseases, and other complaints arising from impurity of the blood, it has only quite recently become used in this country, and now it is greatly in request for consumption, rheumatism, leprosy, and such like diseases, being given both internally and externally. It is being used in several of the London and Parisian hospitals, as well as by some of the leading members of the medical profession. Here, then, is an instance of a new commercial product from India, and one that promises to become an important medicine.

Another plant, which is official in the Indian Pharmacopœia, and which has risen to some importance of late, and promises to become of still more importance, is the *Carum ajowan*, or as it is perhaps more generally known as the *Ptychotis ajowan*, an umbelliferous plant, the fruits of which are used in India as a carminative. These little fruits somewhat resemble in appearance those of the caraway, to which they are botanically allied. The flavour is, however, quite different, that of the plant under consideration having a thyme-like taste and smell. The commercial importance of these fruits as a source of thymol, a valuable antiseptic, is referred to in the *Pharmaceutical Journal* for the 22nd of last month, where we are told that Messrs. Metzner and Otto, of Leipzig, alone sent out, during the months of September and October, more than a ton of this substance. The works of this firm, it is further stated, are occupied day and night in its preparation, and the demand for thymol and thymol wadding is greater than ever. This firm appears to use the fruits of *Carum ajowan* as the source of thymol, but they state that they have advices that not only has the price of the fruits advanced through a bad harvest, but also through the increased consumption of them in India by the natives during the very sickly season of last year. The *Carum ajowan* is an annual herbaceous plant, and, besides occurring wild in many parts of India, Afghanistan, Persia, Egypt, and adjacent countries, is also cultivated in the same districts for the sake of the fruits, which are used in the countries just mentioned on account of their carminative and stimulant properties. Still another new drug—new, that is, to this country, but long known in India—is the rusot (*Berberis aristata*), an extract of the bark of which is now being tried in this country, having been used in India in ophthalmic cases and as a febrifuge from a very early period. The official preparation is the watery extract prepared from the root bark. As the article is quite a new one, as far as English practice is concerned, I am unable to give you any medical opinion as to its therapeutic value. *Berberis lycium* and *Berberis asiatica* both yield a similar product. Turning from drugs, our mind is directed to a peculiar product, which a casual observer would, perhaps, take for deteriorated sultana raisins. Upon closer examination, however, these prove to be the flowers of the mahwa tree (*Bassia latifolia*). This tree grows to 40 or 50 ft. high, with a trunk 6 to 7 ft. in girth, and is abundant in all parts of Central India, from Guzerat to Behar. The tree is propagated by self-sown seedlings. The following notes on this tree were read before the Linnean Society last year by Mr. Lockwood, who spent some time in an official capacity in Monghyr. He says:—

"Any one, standing on the dry metamorphic Kharapoor hills in the district of Monghyr, 250 miles north-west of Calcutta, and looking into the plains below, may see a hundred thousand mahwa trees, which, if fresh from Calcutta, he will probably mistake for mango trees. But, unlike that of mango trees, which are uncertain in their yield, the mahwa crop never fails; for the part eaten is the succulent corolla, which falls in great profusion from the trees in March and April. This season is a great feasting time for the humbler members of creation. Birds, squirrels, and tree-shrews feast among the branches by day, whilst the poor villagers collect the corollas which fall on the ground on all sides. Nor does the feasting end with the day. At sunset, peacocks and jungle fowl steal out from the surrounding jungle to share the mahwa with deer and bears, many of which fall victims to the bullets or arrows of the hunters, who sit concealed in the branches overhead. South of the Ganges, in Monghyr, the mahwa is by far the most abundant tree. It grows on poor stony soil, ill-suited to most other trees or for the plough; and, fully appreciating its valuable properties, the native protect it wherever it grows. During the four years which I passed in Monghyr as magistrate, I visited every part of the 4,000 square miles under my charge in the cold season, paying constant attention to the natural history, particularly to the botany, of the district. The mahwa tree, which I had not seen previously in Lower Bengal, attracted my especial attention; and I calculated that there must be not far short of a million trees in Monghyr alone. Each tree yields two or three hundred weight of corollas; so that the total yield of mahwa flowers cannot be far short of a hundred thousand tons in Monghyr alone. Of this amount a vast quantity goes to feed the forest birds and beasts; but of that portion which is collected by the natives by far the greater part is eaten, and supplies nourishing food to the poorer classes. The Santhals, who use it largely, are a plump and happy race, the only people I have ever seen in India who enjoy a hearty laugh, and this I attribute partly to the nourishing qualities of the mahwa, supplemented with venison and other wholesome game which the woods supply.

"During the season of scarcity which prevailed at Behar during 1873-74, the mahwa crop, which was unusually abundant, kept thousands of poor people from starving, and all famine officers will recall its peculiar odour as they passed through the villages where it had been collected. The residue of the mahwa which is not eaten is taken to the distillery, and there, with the aid of rude pot-stills, is converted into a strong-smelling spirit, which bears a strong resemblance to whisky.

The Government holds a monopoly of spirit manufacture, and when I first went to Monghyr, in 1873, the custom was to charge a duty of eight shillings for every cwt. of the raw material as it entered the distillery, on the supposition that so much mahwa would only yield three gallons of proof spirit. Subsequently, in consequence of experiments made by the officers under me, this duty was somewhat raised; but in England I find that over six gallons of proof spirit can be produced from a hundredweight of mahwa. The Government of India should be made aware of this fact, and it would probably be advantageous to introduce a patent still in the place of the rude machines now in use. The amount of mahwa which nominally paid Government duty yearly in Monghyr was 1,750 tons; but with patent stills under Government control, the mahwa would probably yield a much larger revenue to the State. An Italian gentleman, who was living at Monghyr, when I was there, took out a patent for removing by a very simple process the essential oil, or whatever it is, which gives the mahwa spirit its peculiar smell; and for some time I thought he would make a rapid fortune; orders poured in on him from Calcutta, and the demand promised to be immense. But just as the inventor had taken up a whole side of the Government distillery, and got all his preparations complete, the rum distillers in Calcutta petitioned the Board of Revenue, and a prohibitive duty was imposed, which completely put an end to the manufacture of scentless mahwa spirit. A sample was sent to the chemical examiner at Calcutta, and he reported that the spirit was pure and wholesome, and came very near good foreign spirit."

Besides the uses here referred to, mahwa flowers are stated to be still more useful for feeding cattle. Pigs have been fed upon them in this country, and the flesh pronounced excellent. One great point in connection with these flowers, as a commercial article, is that the crops are never known to fail. Mr. Lockwood further says that the oldest inhabitant in Monghyr had never heard of a season when the mahwa crop was not abundant, for the flowers are always produced in great quantity, whether the fruits afterwards ripen or not. The extraordinary keeping quality of the mahwa is also another recommendation to its introduction into England. Before leaving India, Mr. Lockwood had a ton of these flowers shovelled into sacks and put on board a vessel at Calcutta. They were gathered in April, 1876, and after being kept for nearly two years were as good as when first dried. Mr. Lockwood thinks India would benefit greatly if mahwa flowers met with a demand in England. The vast forests of mahwa trees, which now yield little profit to their owners, would soon become a source of wealth, and the collection of the corollas would give work to thousands of poor people who at present inhabit the rocky country where the mahwa grows. The merits of these flowers for distilling purposes and for feeding cattle seem to be—1, cheapness; 2, unlimited supply; 3, certain yield; 4, nourishing qualities; and 5, good keeping qualities. Besides these uses to which the flowers of *Bassia latifolia* have been suggested for adoption in this country, the oil obtained from the seeds has also received some attention. It is used to adulterate ghee, or clarified butter, and Dr. Cooke, in his report on "oil seeds and oils in the India Museum," says the oil was long since submitted to Price's Patent Candle Company, and its applicability for candle manufacture ascertained. The report states that it is worth in this country, for the manufacture of candles, £8 per ton less than Petersburg tallow. A great many experiments had been tried with it, and it was found to be of the same value as cocoanut oil, as its being harder compensated for the colour being inferior. Large quantities, it was said, could be used in this country at about £35 per ton. This statement was made two years ago, and the value of the oil may have changed since then. That India is extremely rich in oil seeds, a glance through Dr. Cooke's report will show. Apparently there is a wide field here for commercial enterprise. In referring to this subject, a paragraph in Mr. Simmonds' *Journal of Applied Science* goes, I think, quite to the point. We are there reminded that the exports of oil seeds from India are becoming very important, and that India now exports oil seeds to the value of five and a half millions sterling a year, instead of making oil of them there and using the refuse for manure and cattle food, to say nothing about the extra cost of freight. Some vegetable oils are of course exported from India, such, for instance, as castor oil from Calcutta, and gingelly oil from Madras. But European capitalists are wanted to establish oil mills in India, and give their names as a warrant for standard qualities, and then India might hope to make oil one of the chief articles of export. Clever enterprise would soon be amply repaid. There are of course some oil mills in the country, but very few, and in these the oil is by no means made so cheaply as to leave no room for competition. The loss sustained by the country from the exportation of the seeds themselves is simply enormous. In one year four million cwt. of material for oil-cake is sent away, while the cattle are dying of hunger. I give you this for consideration, in the hope that, if the facts are not to be controverted, some steps to remedy such a loss to India may be taken.

It is extremely difficult to particularise any plants specially suited for investigation, as likely to prove commercially valuable; the difficulty is not to find them, where there are so many to select from, but to know which to take first. One man, however, might be specially interested in food products, another in drugs, another in timber, and so on. To the first I would say,—Are there no Indian fruits that we know little or nothing of at present in this country, that could be sent here, if not in their fresh state, preserved in syrup, or candied with sugar? I may instance, perhaps, a few. The guava, for example, is not so well known with us as I think it might be. Guava jelly and preserved guavas we do occasionally see, but they surely might be brought in larger quantities, and sold at a price to bring them into more general use. Then again the rose apple (*Eugenia jambos*), and the fruits of *Eugenia malaccensis*, are quite worth consideration. I have quite recently had an opportunity of tasting candied rose apples from Jamaica, the tree having been introduced into the West Indian Islands, and I can speak highly of their quality, the rose flavour being preserved sufficiently to give them a grateful taste. I am informed by Mr. Robert Thomson, sometime superintendent of the Botanic-gardens, Jamaica, that these fruits are produced in very great abundance, and could be sent into this country in any quantity; steps indeed are being

taken to introduce them to commerce. Of course there is the difference of distance between this country and the West and East Indies, and the consequent greater length of time occupied in transit, and increased expenses of carriage; but if other products can be brought from the East into this country, and sold at a low rate, and yet prove remunerative, I do not doubt that these fruits might also become articles of trade. The loquat, or, as it is sometimes called, the Japanese medlar (*Eriobotrya japonica*), though a native of China and Japan, is largely cultivated in many parts of India. The fruits, which are oval, about the size of a plum or small apple, have a sharp, subacid flavour, and are used as a table fruit as well as for preserving; this fruit might perhaps be found worth introducing preserved either in sugar or syrup. I will only just refer to the names of the blimbing (*Averrhoa bilimbi*) and the carambola (*Averrhoa carambola*), fruits well known in India by cultivation, and valued for their acid flavour, to show that amongst fruits alone there is a wide field for experiment; and, as a further illustration of how unlikely things are utilised, I may mention that in the Java collection of the Paris Exhibition last year, some peculiar looking fruits attracted my attention, which, upon closer examination, I found to be those of the nutmeg, the fleshy pericarp of which had been scolloped or ornamentally cut and rolled back, the whole being preserved in syrup, and forming a very agreeable-looking sweetmeat. Another apparently unlikely fruit to be of any service out of India, where, in Cashmeer, we know it is used, is the singhara nut (*Trapa bispinosa*), the fruit of an aquatic plant closely allied to the water chestnut of the French (*Trapa natans*). The extended cultivation, however, of this plant has recently been proposed in India, and it has even been suggested that the fruits might be sent to this country. I need not dwell on this point, since it has been fully described at pages 174 and 175 of the *Journal* of this Society for January 31st last. In the matter of drugs, the medicinal plants of India are so multitudinous that it is utterly impossible to point out more than two or three by way of example. Professor Bentley and Dr. Trimens' work on "Medicinal Plants," has, no doubt, been the means of drawing attention to many plants which, though official in the Pharmacopœia of India, are still unknown so far as medical practice is concerned. Thus, a common leguminous tree, known as *Butea frondosa*, yields a resin known as Butea or Bengal Kino, which exudes from the trunks of the trees either spontaneously or by incisions; this kino is an official remedy in India, being used in the same way as the ordinary kino of commerce. Other species of *Butea* help to furnish this kino, which is not altogether unknown in this country, being occasionally used as a tanning and dyeing agent. The seeds of the *Butea frondosa* have a considerable reputation in India amongst the Mahommedan doctors as a febrifuge; their use, however, is said to be sometimes attended with ill effects, hence further observations on their action is desirable. The oil obtained from the seeds is used as an anthelmintic. Some further researches in England on the products of this tree might lead to advantageous results. Another important medicinal plant included in the Indian but not in the British pharmacopœia is the *Dipterocarpus turbinatus*, a large tree found in the forests of Eastern India from Chittagong and Pegu to Singapore. By incisions made in the trunk, and by the application of heat, a balsamic exudation flows. The average produce of the best trees during the season is said to be sometimes as much as 40 gallons. This oil, or oleo-resin, is known as gurjun or wood oil, and is described as being an effectual diuretic, suitable for use as a substitute, or in place of, copaiba balsam. It is not impossible that ere long we may hear something more of this oil in our hospitals.

In the matter of new woods, whether for building or cabinet purposes, time will not allow me to enter. It is a question, moreover, that may safely be left to the forest conservators. Suffice it to say that the first consignment of Indian timbers for commercial purposes arrived in this country not many months since, some of which were favourably received. In view of the scarcity of boxwood from the Caucasus, the possibility of India coming to the rescue is a fact to be thankful for.

With these few suggestions, which might have been extended *ad infinitum*, I will draw my remarks to a close, hoping that my poor attempts to draw attention to Indian plants adapted for commercial purposes may not have been uninteresting, and, moreover, may lead to some further development of India's resources.

DISCUSSION.

Mr. Christy thought the Society was much indebted to Mr. Jackson for his remarks. He mentioned the chaulmugra seed as having been known for many years; and from information he had received, and papers that his cousin, the late Mr. Daniel Hanbury, had published, it appeared that it was known for many centuries in China, being always brought from India. It was very rare to find it in a pure state, one reason being the great expense, and the Chinese almost always adulterated it. He had had immense difficulty in introducing this oil here. He was on the committee of St. Peter's Hospital, and having this oil here, and having used it for one of his children with marked success, he placed it on the committee table for the surgeons, and begged them to use it. They thought the smell would be objectionable. Having waited a month, and nothing being done, he attended the surgeons and stood by them when they were seeing their out-patients. Knowing them intimately, he suggested—Is not this a case for gynocardia? They said, certainly. In a few minutes another case came forward, and he suggested it should be tried in that also, and as the man was asked to come again in a week he took care to be present. The surgeon was very much surprised by the result, and in the second week the man was nearly well. The surgeon said, "Be sure you come next week," and on the next occasion he seemed quite cured. These were cases of skin disease and syphilis, and were most trying. The surgeon then said there was really something in this oil, and he took it into regular use, and the result was most satisfactory, and he hoped there would soon be a report upon it. He had also sent it to Mr. Treves, at Margate, who had a great many cases of scrofula, and he had also tried it with marked success. He merely mentioned this to confirm the remark of Mr. Jackson, showing the difficulty there was in getting anything new tried. A gentleman in a Government office, knowing he was working at these new things, asked him if he could tell him of anything which would cure his brother, who was suffering from rheumatism,

and was almost stiff with it, and who had been getting worse for 25 years, the only relief he could get being from chloral. He told him he could not take any responsibility, but if he liked to try some of the oil he would give him some. The brother took five capsules, each containing five drops of the gynocardia oil, and on the sixth day he dressed himself and went out, and he had been well ever since. He now carried about a bottle of the oil with him. That showed what might be done if people would only work with these things. The Chinese had been working with this oil for 500 years. The week before last, he was in Paris, and was asked to meet some of the surgeons there. They said it was a very singular oil, and that it sometimes produced indigestion. He said he knew it did, but it was quite safe, as far as he knew, if taken on a full stomach. He was sure, if this was worked at in our hospitals, there would be an enormous demand for this oil. Thymol was also a very valuable drug. Tamarisk galls, again, were entirely unknown in Eugland. It was knowu, since Ramspaecker discovered an apparatus for testing the exact value of tanning materials, that galls only assisted the tanner by opening the pores of the skin, to allow tanning substances to enter; but it was formerly believed that the galls themselves assisted the tanning operation. Now, these tamarisk galls had been brought over many times, but very few tanners knew anything about it; it collected in the docks, and was sold at the rummage sales. Tanners were very anxious to get it in quantities. *Balsamocarpon* was now growing in Iudia; he had sent some seed to India and Australia, and it was the richest tanning substance in the world, containing 90 per cent. of pure tannin. He also showed a specimen of russot. This was being used by some of our oculists; it had been used for a long time in India, but no report had been issued upon it. The mahwa he had also worked at. He had had some of the fruit in a sack since 1876, and there was no change in it whatever. The fleshy corolla fell from the trees as had been described, and it was eaten with avidity by all kinds of animals, even the carnivora. Some was taken to the Zoological-gardens, and there was hardly an animal or bird there but ate it readily. He sent some to Paris, where there are so many professors that they were always anxious for something new. They tested it for spirit, and their report was that it contained the very highest class of spirit they had had submitted to them, and yielded a larger per-centage than any fruit hitherto tested, and they could hardly believe that it was a flower. It was very singular that this fruit could be landed in England from India at 6s. a cwt., and if six gallons of proof spirit could be made from the cwt. it would be very profitable. It had been offered to the distillers, and they said they should be glad to give £8 to £9 a ton for it. He had written to India for 20 or 30 tons, and though there were difficulties about the transport, he hoped it would soon be sent over.

Mr. Hale said he believed that England, with the produce of India, might be independent of all the world; and he thought representations ought to be made to the Indian Government to try these products, and send over larger quantities, so that the resources of the country might be developed.

Mr. Holmes agreed that it would be wise if the products of India were examined there instead of at home, and some of them sent over here for commercial purposes. One reason why products were neglected was because many of the things sent over were of very little value; another reason was that they were not sent over in sufficient quantities. If Government were to send over some of the products which were considered most valuable by the ton, and put them into the hands of thorough men of business, many of them would speedily be introduced. At present they simply figured in museums, and there were no opportunities for commercial men to test them. He was especially interested in drugs, and on them Mr. Jackson's remarks were very valuable. Indian aconite, especially the Nepaul, when it could be obtained, was eagerly bought up for the manufacture of the alkaloid, because the aconitive in Indian aconite was more powerful than the German. If it could be sent over at a paying price, it would be sold in large quantities. The opium used in this country did not come from India, and it was difficult to find a specimen in this market. It all came from Smyrna, Persia, and Egypt. Now India was a great opium-producing country, and he saw no reason why, if prepared of good quality, it should not be largely used; it only required more care in the preparation. Thymol was another instance of what might be done by a little business energy. It was a powerful antiseptic, and derived its name from occurring in the common thyme; it was now coming largely into use, being safer and less irritating than carbolic acid. With regard to russot, as a rule the extract was rather impure, and appeared to be used from the earliest times, iu India, as an application to inflamed eyes. It probably owed its good properties to ferberine, which was also found in India. Dr. Dymock had lately sent him over some Mangostine fruit, unripe, preserved in syrup; the flavour was very pleasant, and it occurred to him that if it were once tasted, it would be much inquired for. Mr. Jackson also alluded to the gingelly balsam, which had been brought into notice as a substitute for copaiba. In leprosy it certainly did not answer as well chaulmugra oil, but it was very cheap, and it would no doubt find numerous applications in the arts, if not in medicine. He could quite confirm what Mr. Jackson had said about the chaulmugra oil. He had lately read a letter from a chemist in the Mauritius, who said it was impossible to obtain pure oil from India, and that he always sent for the seeds. He found the oil obtained by boiling the seeds was stronger than that obtained by cold expression.

Mr. Routledge said he, unfortunately, had no samples of bamboo with him, or he should have been pleased to show them. The subject was of immense importance to paper makers, who at present were almost entirely dependent on foreign countries for their main raw material, viz., esparto grass. He was sorry to say that this material was beiug more rapidly exhausted than he had deemed possible; only a few days ago he had samples of Spanish grass submitted to him, some of which was not more than 4 in. long. The fact was, it was overpulled, the roots were laid bare, and the winter rains washed away the soil, so that the root stools became impoverished, and in many districts the plant had almost vanished, where hundreds and thousands of tons grew formerly. The largest supply now came from Africa aud Algeria, and there it was going through the same process of exhaustion from the same causes. It was therefore necessary, if the manufacture of paper were to continue, that some new material should be discoverd; for makers were now reduced to using things such as ground wood pulp, china clay, aud other matters which never ought to be put iuto paper. Some of the cheap papers almost fell to pieces in your fingers. For some time past he had been turning his attention to bamboo, believing, from investigation, that it would prove the best and cheapest material which could be used, and possessing also the enormous advantage of being produced in illimitable quantities in India. The Chairman would bear him out that three-fourths of the country produced bamboos; in fact, it grew almost anywhere where there was moisture. There had been a controversy going on for some time between him and Dr. Kiug, curator of the Botanical-gardens at Calcutta, as to the cultivation of this plant in India, the latter maintaining that it could not be grown or cropped. He believed it could, aud he had proved that it would make most excellent paper. The pamphlet Mr. Jackson referred to was printed on paper

made from bamboo, and better paper he did not want to see. Dr. Winthrop, the Commissioner of Forests in Burmah, was collecting bamboos for him, and he wrote him that they could be landed at Rangoon and floated down at a cost of 15 rupees per 1,000, weighing from six to eight pounds. When dried they lost about 60 to 70 per cent. of moisture; so that practically, a ton of dry raw fibre would cost 30s., and that would produce a ton of paper. The bamboo gave the greatest yield of any material he was acquainted with, except perhaps one, the paper mulberry tree. All fibres have to be submitted to a boiling process, during which they lost a large quantity of extractive matter, varying from 40 up to 60 per cent. of the weight of the plant. The bamboo only lost 40 per cent., whilst esparto was supposed to lose 50, but in practice, it was about 46. The test of a fibre as regarded its commercial value was, first, what quality of paper it would make, and next what it would cost to produce the paper. The lowest price of esparto at present was £6 a ton for the raw material, or, allowing for a loss of 50 per cent., £12 a ton. The bamboos could be floated down at a cost of 15 rupees (30s.) for 2 tons of dry material. The unfortunate part of the matter was, that India was such a long way off, and bamboo was very light and bulky. It also contained a large quantity of moisture, so that, if crushed, it had a tendency to ferment and rot. For these reasons he believed that, to make it pay commercially, it must be treated on the spot, and sent over in the condition of what was called stock. The point at issue was whether it could be grown and cropped. By the last mail from Demerara he received two letters, one stating that for three years the writer had cut down whole bamboos, and he did not see any depreciation in the succeeding growth. In the other letter the writer said he had seen bamboos flowering on his estate, and they remained healthy afterwards. The theory in India was, that when a bamboo flowered, it died. There were very many varieties of the plant—probably about 120—and the majority were supposed to attain maturity in about 40 or 50 years, when they flowered and died; but in the West Indies that did not seem to be the case. This gentleman said he had had them cut down and burned, and, in a few months, they were as flourishing as ever. He had several other letters to the same effect. The one thing the bamboo seemed to want was a damp, moist climate; it was useless to attempt its cultivation where these conditions were wanting, but in Burmah, where the rainfall ranged from 120 in. to 160 in. all up the west coast, it flourished in great abundance. He had letters from the Assistant-Conservator of Forests there, who had travelled over the whole country, right up beyond Pegu, and he said that the natives cut it about anyhow they liked, and the more they cut it the better it seemed to grow. He believed the safest plan would be to cut a certain portion of each clump every year—the young shoots; but if a plantation were made, as was done with sugar, rice, jute, and other things, it would minimise the cost of collection and carriage, and it could then be irrigated if necessary. If so grown, he believed you could get enough bamboo for 20 tons of paper per acre. We should then be independent of France, Spain, and Africa; and he feared the French Government might, before long, impose a duty upon esparto, seeing it was an article of such prime necessity. It was an absolute necessity in these days that we should have paper, and he wondered that this question had been allowed to lag so much. For his part, however, he did not intend to relax his exertions until he had brought them to a successful issue.

Sir Joseph Fayrer said Dr. King was a most eminent practical botanist, and if he said the bamboo would not grow in Southern India, it was difficult to question it, but he certainly accepted the statement with the greatest diffidence. He believed if the bamboo would grow anywhere, it would grow in Bengal, and in Burmah. He could not conceive how anyone who had lived and travelled in India as he had done, and seen the magnificent clumps of bamboo, even in and about Calcutta itself, could maintain that it would not grow. By judicious cultivation, he had no doubt it could be cropped regularly. He had no idea that it had such a great commercial value, and it seemed to him a thousand pities that it should be neglected; and he hoped what Mr. Routledge had said would be acted upon. He might also allude to the kindred subject of arboriculture. The mahogany tree, although an exotic, grew freely in India, and some splendid trees which were blown in the Calcutta-gardens by the last cyclone, were sold for cabinet making, at prices equal to that of the best timber from Honduras. He had often wondered why the roads in Bengal should not be lined with it; it formed a magnificent shade, and the wood was very valuable. Dr. King was a most excellent and energetic curator, and he felt great difficulty in suggesting anything which might appear in anyway to controvert the opinion he had given, but he could not help thinking there must be some mistake about it. He regretted the paper was not longer, but it was quite sufficient to indicate the direction in which search was to be desired. It was very desirable, however, that many of these things should be more used in India itself. India was indebted to England for many products which she could produce as well herself. The impetus had already been given, and many things were now sent over here which a short time ago were quite unknown. The chaulmugra oil was well-known to him, and it was a most valuable medicine.

Mr. Francis Cobb said that many present probably were not aware of the obligations they were under to Mr. Routledge for his experiments, and the perseverance with which he had followed up the question of bamboo for paper-making. His idea was to bring the bamboo to a certain stage in India, as shown by a small specimen which he would hand to the Chairman. This was not the first time Mr. Routledge had told them about the bamboo, and he was surprised that it had not been taken up to a larger extent. Bamboos were constantly brought here in the shape of dunnage, but they arrived in such a condition as not to be so fit for the purpose of paper-making as if it could be brought in the condition he had shown. The outside was hard, flinty, and unmanageable. But it was evidently erroneous to suppose that the bamboo could not be utilised and become a valuable export from India, as was shown by the practice of the Chinese. They cut off the young shoots and ate them, and split up the young bamboos and made use of them in all sorts of ways. On the other hand they let some grow so large that they made buckets of them. If the Chinese could treat them in this way and still have a constant supply, he could not see why it should not be done in India, especially if they were grown in plantations. Mr. Jackson regretted that oil seeds were exported instead of expressing the oil in India, but it appeared to him that the oil could be much better expressed in England, and the profit arising from the process was in the form of a bye-product—the cake, for which there was a good market. He doubted if anything like a market could be found for it in India, where they did not fatten bullocks for eating. The price of the cake here was about £2 a ton, and he did not think anything like that could be obtained in India. The bamboo, however, opened a prospect which there was no seeing the end of. The greater the quantity supplied, the greater would be the consumption, especially at esparto was failing, and in a few years would be at such a value that it would be no longer available for paper-making. If there was a country in the world where opium was raised, it was India, and probably Mr. Holmes was referring to laudanum; but he believed that where Turkey opium could not be obtained, the Indian had been used for making the tincture. So long as the medical man knew what he had, the Indian was as good as the Turkish,

and it was merely a question of the rules of the British Pharmacopœia as to what should be called laudanum. No mention had been made of Rhea grass, which, if cultivated in India, would form a very valuable export. It was known here chiefly as China grass, but it might be cultivated largely in India. There were also what was called vegetable silk, or wild silks, which were worthy of more attention.

Mr. Routledge said the first experiment he made with bamboo, some five or six years ago, on the ripe, matured plant, but it did not answer well. The young bamboo sprang from the seed of the old plant, and it took about 15 years before it became silicious. No matter what species it might be, it went on maturing for a series of years, and being an entogenous plant, it grew until the inside got filled up and it could grow no longer. It could then no longer transmit the sap, its pores, or vessels, became ossified, like the veins of an old man, and it died, having first seeded. The bamboos which came here as dunnage were cut indiscriminately from the clumps, irrespective of age, and in the older ones the exterior portions had got so indurated with silicia, that it took an enormous quantity of caustic soda and high pressure boiling to make it manageable. It was then no longer a fibre, but a pulp, which was difficult to dry, and would only produce inferior paper. If they wanted to make paper from wood they need not fetch bamboo from India, because they could get it much cheaper nearer home. After making these experiments on the old matured wood, and finding the difficulties he had to contend with, he was induced to try what he could do with the young plant, and he found, much to his gratification, that very much like esparto grass when the plant was cut with the sap ascending, the young shoots, which ran up 50 or 60 feet high, it could be reduced by gentle boiling into the consistency of cheese, aud might be treated with the same felicity as esparto; in fact, it was just like cooking a ripe cabbage, or asparagus. In fact, in the Malaccas and Maluccas, the young shoots of some species were used for food, and were frequently put in pickles and chutnees.

Mr. Bowden said he should be happy to place five acres of ground, in the Godavery district, under irrigation, at the disposal of anyone who would like to experiment on bamboo cultivation free of rent. There were cheap means of transit from there to the port of Coconada.

Mr. Geo. Hogarth asked if rhea, one of the most beautiful fibres, was produced in India. He was sorry to say that it was losing ground, the entire responsibilty of which lay with those who produced it and prepared it for the market. It was so carelessly put together, that the great bulk of it was useless for anything but paper-making, simply because it was all twisted and gnarled, and there was no possibility of getting it straight. When properly garnered, there was nothing to equal it except silk, and it was being manufactured into everything a lady could adorn herself with, but, as he had said, it was losing ground from the bad state in which it came over. The price ranged from £5 to £80 a ton, which showed what a margin there was to pay for careful preparation. He understood that hitherto it had been retted entirely by hand, which was very expensive, though labour was cheap. The Indian Government had offered prizes for machinery to do it, but hitherto nothing satisfactory had been devised.

The Chairman said the rhea which came from India was often badly prepared, but the China grass was beautifully prepared, and could be obtained in any quantity.

Mr. Hogarth said all he had seen was the common China grass. He understood that a great deal of the difficulty lay in the gathering; if it was not ripened sufficiently in the sun after cutting, there was a deal of acid left in it, which made it snarl in the process of manufacture, and prevented it taking the dye.

Surgeon-General Balfour thought a good deal might be made of the various products of India. Bamboos were grown in enormous quantity on the west coast, they were never shipped, on account of their great bulk, but were made up in rafts and lashed to the sides of the coasting vessels. The great question with all India products was—would they pay? and he believed that most of those which would do so were already brought to Europe. The natives were well alive to their own interests, and are not much disposed to make experiments unless they could see their way to a profit. He doubted if it would be possible to obtain a large quantity of chaulmugra oil, but there was no doubt of its value. He believed it was the oil which the late Dr. Bhau Dajee used in the cure of leprosy, but both he and his brother kept it a secret. There was a great difficulty in getting it pure. Nearly all the eminent medical men who had written on India and its products had drawn attention to the various commercial products, but it did not seem to produce much effect. There was abundance of opium in India, and he did not know why it did not come to England, but he believed that some of the active properties were more abundant in the Turkish opium than in that of Bengal. The great difficulty with many articles was their great bulk, nevertheless enormous quantities of jute were now brought here, and quite a large industry had grown up in Dundee and elsewhere in its manufacture. One great difficulty in exporting oils was in obtaining the barrels to put it in. At one time a considerable trade was done in solidifying castor oil, by a process invented by Mr. Loarer, so that it could be sent home in blocks. That lasted for a few years, but it did not seem to have been continued.

Mr. Christy wished to utter a word of warning to Indian exporters. He had learned that week that it was with the greatest difficulty that manufacturers could now use Indian shellac, owing to the quantity of resin and other adulterations which were mixed with it. The people of India had been down on the English manufacturers for charging their cotton cloths, but we could certainly retaliate on them for charging their shellac with resin. With regard to the expression of oil and the use of the cake, he might mention that the Chinese found it pay very well to use the cake direct on the land for manure.

Mr. Cobb suggested that this was not oil cake but pea cake.

Mr. Christy said that was so. Mr. Routledge's views about cropping the bamboo were quite correct. In China they kept regular plantations which were constantly cropped, and descended from father to son; a certain quantity was cut out of each clump every year.

Mr. Holmes added, with regard to opium, that the best authorities on the subject said that the better qualities were not prepared in sufficient quantity to export to England. It was the Patna opium which was chiefly used in the hospitals. Some said it contained more narcotine and less morphia than that from Asia Minor. The fact of its not appearing in the Pharmacopœia would not stand in its way if it were equally valuable, because the Persian opium, which was not named either, was largely used by the makers of morphia when Smyrna opium was dear. The Indian opium, he believed, was prepared in a different way, being brought home and stirred up into a paste, whereas the Smyrna was made directly from the capsules; and probably this affected the quality.

Mr. Cobb thought the true reason why Indian opium was not used was, that the per-centage of morphine in it was uncertain; so that, when you gave a patient 30 drops of laudanum, you might really be giving him the equivalent of 45. Hitherto, also, the Turkish opium had been landed in England rather cheaper than the Indian.

The Chairman proposed a vote of thanks to Mr. Jackson. All the products he had mentioned had a future, and probably a considerable future, before them; but he would call attention to another product, which had not been mentioned, for which we paid on an average upwards of 30 millions sterling per annum, viz., wheat. He had placed on the table a number of samples of Indian wheat, which represented 1,100 or 1,200 specimens sent from all parts of India. The samples came from some 60 districts, and they were equal, and even superior, to the finest wheats which came into the English market. The average price of English wheat at the present time was about 38s. a quarter, but that of the samples referred to went as high as 47s., and some of them weighed 65 lbs. to the bushel. It might not be known to all, but India was, next to the United States, the largest wheat-producing country in the world, the annual crop being about 30 million quarters, 10 to 11 millions in the Punjaub—about as much as the whole production of England—10 millions more in the North-West Provinces and Oude, and the remainder in other districts. The average production in America was about 38 to 40 million quarters. There had been a remarkably good crop last year, and this together with the universal commercial depression and want of confidence, which prevented importers holding large stocks, was one cause of prices being so low, lower he believed than they had been during the present century. He believed there was a great future for the Indian wheat trade. The year before last we imported upwards of a million quarters; this year the supply had fallen off on account of the demand in India itself, but by the opening of the Scinde Railway he thought they might look to the day when the Punjaub alone would be able to send us a very considerable quantity, for it produced more wheat per head of population than any other part of India. When the Indus Valley Railway was opened, especially when the bridge over the Indus was completed, the reduction in the cost of carriage, as compared with going to Calcutta, would be equal to about 8s. a quarter, enough to make all the difference between a paying and a non-paying trade. Prices at present were exceptionally low, but were not likely to remain so, and with a slight rise he thought there would be every possibility of obtaining large supplies from India at a profit. This was a matter of extreme importance both to England and India, and might have an important influence on the silver difficulty with which we have to contend at the present time. The finest wheats at the Paris Exhibition were not superior to some of these from India.

The resolution having been passed,

Mr. Jackson, in acknowledging the compliment, said Mr. Christy had fully borne out what he said as to the prejudice against new products. With regard to Indian opium, the greater part of it was sent to China, where it was illegal to produce it; but still a good deal was made, and he believed the Chinese Government were contemplating allowing it. He must apologise to Mr. Routledge for not having asked him to bring some specimens of bamboo, but the subject had entirely slipped his memory. He had referred to the *Brucinicia paperifera*, which was are markably good paper-making material, and was well known in Japan. There were two species, from which they made nearly all their paper. By treating it with oil, they made it transparent, and used it for glass; and, by putting several layers together, they formed a material similar to leather, which they used for book-binding and other purposes. The utilisation of Rhea fibre in this country was another illustration of how difficult it was to introduce new substances. About 25 or 30 years ago, this fibre was brought prominently under notice by the late Sir Wm. Hooker, and it was sent to several British colonies, but nothing more was heard of it until 10 or 15 years ago, when it cropped up again in a most remarkable way. The American Consul at Bradford had sent a report to his Government, drawing attention to this fibre, and pointing out that it might be introduced into some parts of the States. This report fell into the hands of the British Government and was sent to Kew, with a request that the plant should be introduced there, and asking whether it was suitable for introduction into any of the British colonies, exactly what had been done long before. It was then again introduced into the West Indies and other colonies; but it again died out. The Indian Government had offered a large premium for a machine for clearing this fibre in India, because as he understood the great difficulty in the manufacture was the large quantity of gum contained in the bark, which rendered it necessary that it should be cleaned and prepared in the green state. For this purpose plants were grown in the South of France, so that they might be experimented upon. It was a hardy plant, and grew very well there. Some of the specimens in the Kew Museum were extremely fine, and he saw no reason why it should not be largely grown. Why it was not brought into more use was one of the mysteries which seemed inexplicable.

FOURTEENTH ORDINARY MEETING.

Wednesday, March 12th, 1879; WILLIAM ELLIS, F.R.A.S. (Superintendent of the Magnetic Department of Greenwich Observatory), in the chair.

The following candidates were proposed for election as members of the Society:—

Chambre, Alan Edward, Camera-lodge, South Norwood, S.E.
Cheston, Charles, 5, Clarence-terrace, Regent's-park, N.W.
Phillips, Samuel E., 14, Charlton-villas, Church-lane, Old Charlton, S.E.
Roberts, Owen, M.A., Clothworkers'-hall, 41, Mincing-lane, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Maxse, Rear-Admiral F. A., the Chestnuts, Wimbledon-common, S.W.
Reid, Frederick William, 79, Queen-street, Cheapside, E.C.
Reid, George, 79, Queen-street, Cheapside, E.C.

The paper read was—

ON THE COMPENSATION OF CLOCKS, WATCHES, AND CHRONOMETERS.

By Edward Rigg, M.A.

(Assayer in the Royal Mint).

With very few exceptions, the mechanical arrangements used for the measurement of time are regulated by a more or less heavy body, oscillating in a circular path round a centre of motion. In stationary clocks, this control is obtained by means of a pendulum, under the influence of gravity; and, in portable timekeepers, by a balance, independent of the directive action of gravity, but subject to that of a delicate spring.

The motion of the train of wheels being solely determined by the release of a tooth of the escape-wheel through the motion of this regulator, it will be evident that each of its oscillations must be performed in the same period of time, in order that the hands may continue to travel with constant velocities. Various circumstances, however, tend to prevent our attaining this absolute uniformity,

and any device introduced into a timekeeper, supplementing the mere mechanism required to maintain the motion of the regulator, or the application of any principle in such a manner as to make the uniformity more perfect, must be included under the term "compensation." The subject, then, has a very wide significance, and it would be impossible, in a single paper, to profitably discuss the several phenomena that interfere with the going of a timekeeper; but it may be well to draw attention to the following table, which gives the influences that are of primary and secondary importance in two separate classes.

Class I.

1. Motive force.
2. Isochronism.
3. Heat.

Class II.

1. Atmospheric pressure.
2. Electricity and magnetism.
3. Hygrometry.
4. Gradual acceleration (in chronometers).
5. Gravity.

It is only intended to consider the third in Class I. (Heat), and the first in Class II. (Atmospheric pressure), with any degree of completeness, but a few words on the other points may not be out of place.

The well-known fusee and chain of the English watch and the chronometer, and the very great variety of constant force or *remontoire* escapements, were introduced to neutralise the want of uniformity in the force exerted by a coiled spring; but the opinion is now held by many, that in watches intended for ordinary use, where very great accuracy is not needed, the force, although far from uniform, will give satisfactory results, if the spring be so proportioned to its barrel that it requires about four turns of the key for complete winding up, only three of which are ever called into action for the purpose of impelling the train. In frictional rest escapements, such as the horizontal, the resistance to the motion of the balance, owing to the pressure of the tooth, increases as the motive force increases, and in this way the mechanism itself compensates, approximately, for any variation in the force.

Strictly speaking, of course, isochronism should include the entire subject of compensation; for all that we require is to cause each oscillation to occupy the same period of time; but the term is exclusively used to refer to that fundamental condition, in virtue of which the duration of an oscillation of the regulator is entirely independent of the amplitude of the arc described. A pendulum requires to move on a cycloidal curve for its oscillations to be isochronal, and, if its path is circular, the long arcs occupy a longer period. The experiments of Winnerl and Laugier* prove that the length and thickness of the suspension spring and the weight of the bob may be so correlated as to give isochronal motion; and Dr. Hipp† points out that the escapement, suspension spring, &c., may have a like action. A method of isochronising the motion of a pendulum was exhibited by Loseby at the Exhibition of 1851, but it was not found to be successful when tried. The length of the balance-spring of a chronometer or watch may be so adjusted that the force of its elasticity is exactly proportional to the angle through which the balance is turned; when this is the case, the vibrations of the balance will be isochronal. This point is generally found at about the eighth coil in a cylindrical spring, and the twelfth coil when the spring is a flat spiral; with a greater length the balance will lose in the long arcs as compared with the short arcs, and with a less length the reverse is the case.

* "Comptes Rendus," 1845.
† "Journal Suisse d'Horlogerie," ii., 85.

Very little is positively known as to the precise nature of the action exerted by electricity and magnetism on chronometers. Experiments were made by Fisher and Barlow in 1820, by Harvey* in 1824, by Arnold and Dent in 1833†, and others. A remarkable change in the rate is at times observed on transferring a chronometer from the Observatory on board ship, and this has generally been regarded as due to the magnetism of the vessel; Delamarche and Ploix‡, however, satisfied themselves experimentally that this cause was not sufficient to account for so great a change. When the atmosphere is charged with electricity, the chronometer is known to vary in sympathy with the magnetic needle, generally causing an acceleration in the rate. The same is the case in magnetic storms.§

When a deal pendulum rod is employed that has not been properly prepared, it will expand, in a damp atmosphere, through the absorption of moisture; the clock will, therefore, lose on its rate. In chronometers, damp air is detrimental, in that it gives rise to oxidation of the highly-polished surfaces. Dent believed that the oxide thus formed on the surface of the balance-spring increases its elastic force, and thus occasions the remarkable acceleration that is observed to occur in the rate of a chronometer after it has gone for some time, an acceleration that at times amounts to as much as 4 or 5 seconds a day after two years. M. Robert,‖ however, considers the thickening of oil a more probable cause. C. Frodsham¶ considered it to be caused by a change in the molecular state of the spring, but Villarceau** has shown that, under certain conditions, it may be occasioned by resistance at the balance pivots, thus confirming M. Robert's view.

Finally, the difference in the value of terrestrial gravity at various points on the earth's surface causes a corresponding change in the rate of pendulum clocks, but is without influence on timekeepers that are controlled by a balance. For the formula for the period of an oscillation of a pendulum shows that it depends, other things being equal, inversely on the square root of the value of gravity as usually measured; so that an increase of this force, in geometrical progression, causes the rate of the clock to increase arithmetically. Under this heading may also be included the variation in the centrifugal force due to the earth's rotation, which is zero at the poles, gradually increasing to

* "Brande's Quarterly Journal of Science" (1824), xvii., p. 364.
† "Nautical Magazine," ii. (1833), 262.
‡ "Comptes Rendus," xlviii., 462.
§ "Revue Chronométrique," iv., 471.
‖ "Revue Chronométrique," vi. 329, and "Horological Journal," xi. 37. See also a letter from Mr. Knudsen at p. 79.
¶ Reports of Juries, 1862.
** "Annales de l'Observatoire de Paris," t. vii., p. 2.

a maximum at the equator; but it is very rarely that such influences as these need be regarded.

Compensation for Thermometric Variation.

It must not be assumed that what is known as a compensation pendulum or balance can be applied with advantage to any form of clock or watch. In either case, rapid manufacture and low price may render unavoidable faults of construction, that give rise to greater variations in the rate than are caused by temperature; and any form of compensation that is not accurately adjusted and well suited to the train, may occasion greater irregularity than would be experienced on replacing it by a pendulum or balance of ordinary construction. A change of temperature will influence the rate of a clock in two ways, only one of which sources of irregularity can be corrected efficiently by means of a compensation pendulum. It will produce a change in the acting surfaces through variation in the consistency of oil, &c., and it will alter the length of the pendulum. A reduction of the temperature below zero, as well at excessive heat, has a very detrimental effect on the oil, and, with a plain steel pendulum, the mere change in its length will only cause a variation of 0·53 second in 24 hours for each degree Centigrade rise or fall of temperature (or 0·3 second, using Fahrenheit's scale). It follows that an uncompensated steel pendulum, that is correct in spring temperature, will only lose through expansion 1′ in the hottest fortnight of summer, and gain a similar amount in winter.

Escapements may be divided into two classes, frictional rest and detached escapements. In the first, such as the verge and horizontal escapements in watches, or the Graham escapement in clocks, the pendulum or balance is never free from the mechanism by which it is driven; but in the second class, of which the lever escapement in watches may be taken as an example, the pendulum or balance only engages with the train long enough for the impulse to be applied. Now, all the acting surfaces must be supplied with oil, and, as the consistency of this is modified by temperature, a varying resistance is opposed to the motion of the balance when a frictional rest escapement is employed. The irregularity which this variation gives rise to in the rate is commensurate with that caused by expansion due to the change of temperature, and it evidently cannot be permanently counteracted by any system of compensation, since it depends on the age of the oil, &c. This disturbing influence has the greatest weight in watches; it is of sufficient importance to render compensation balances useless, and they are, therefore, never employed with this class of escapement. Moreover, such watches possess a kind of natural compensation of their own, for, as will be presently seen, the tendency of a watch is to gain in cold weather, and at the same time the oil will become thicker, and offer an increased resistance to the motion of the balance. The converse will be the case in warm weather. Clocks with undetached escapements are also subject to this influence, but in a less degree.

The conditions of the problem of compensation in clocks regulated by a pendulum, are so entirely different from those met with in timekeepers that are regulated by a balance and balance-spring, that it will be necessary to consider the two cases separately. We will begin with the more simple case of the pendulum.

The well-known formula for the time of oscillation of a simple pendulum* shows that this period varies with the square root of the length, and calculation shows that an increase of $\frac{1}{720}$th the initial length causes a loss of one minute in 24 hours. From these data it is easy to determine the effect of a given rise or fall of temperature, if the material of which the pendulum rod is composed be known. It is only necessary to multiply together the co-efficient of linear expansion per degree, the number of degrees change of temperature, and 720, to obtain the alteration per 24 hours in minutes. Thus, for a rise of 20° Centigrade (36° Fahr.) with a steel pendulum rod, for which the coefficient of expansion per 1° Centigrade is 0·0000124, the clock will lose 10·7 seconds on its daily rate.

The most obvious mode of diminishing the sensibility of the pendulum to variations of temperature is to employ a material for the rod that is but little influenced by such changes. Glass and wood have been suggested, but the former is objectionable on account of its fragility. Very good results may be obtained with a carefully made wooden pendulum, and well seasoned deal is usually employed, but M. Winnerl, of Paris, recommends the wood used for the sounding-boards of pianos as the best. In any case, it must be straight-grained and without faults, and it is advisable to make the bob cylindrical instead of lenticular, since the rod is liable to twist through torsion. The principal objection to the wooden pendulum, however, lies in its sensitiveness to variations in the hygrometric state of the atmosphere. In 1834, Baron de Prony made experiments on varnished and unvarnished deal rods, to determine the effect of moisture, and he found, with the hygrometer at 70° (saturation being 100°) that the varnished rod showed a loss of only 1·07 sec. in 24 hours, as compared with its rate in dry air; whereas the elongation of the unvarnished wood occasioned a loss of 2·98 sec. M. H. Robert, a celebrated French clockmaker, soaked the wood in a drying oil after having thoroughly seasoned it; the wood was then left to dry and was varnished; he also avoided the effects of moisture by enclosing the rod in a brass box. Kater mentions that a gilded teak rod is unaffected by moisture; and, finally, Sir E. Beckett proposed that the rods should be subjected to a creosoting process.

It is unquestionable that a carefully made wooden pendulum is to be preferred in all clocks, other than the very best astronomical clocks; in conjunction with a well-made train, it can be relied on to give a more uniform rate than any unadjusted compensation pendulum; indeed, such a pendulum may give rise to very great irregularity if, as is perfectly possible, the arrangements for compensation tend to produce an opposite effect to that which is required.

An immense variety of devices have been pro-

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* $t = \pi \sqrt{\frac{l}{g}}$ where l is the length of the pendulum, g the value of gravity (32·2), and π the ratio of the circumference to the diameter of a circle. If two pendulums of lengths l and l^1 differ to the extent of one minute in 24 hours, it may be shown that $\sqrt{\frac{l^1}{l}} = \frac{86400+60}{86400}$, and hence we obtain $\frac{l^1-l}{l} = \frac{1}{720}$ very approximately.

posed for correcting this error of temperature, but they may be classified under four heads:—

1. Two or more solid and rigid substances employed in conjunction, and so arranged that the vertical downward expansion of one is neutralised by the vertical upward expansion of another.

2. Two metals of different expansibilities actuating levers, and thus maintaining the length of the pendulum invariable.

3. Two metals of different expansibility, rigidly joined together by soldering or otherwise, employed to vary the distance of a weight from the centre of suspension whenever the temperature varies.

4. Pendulums in which mercury is employed.

Before referring to examples of these classes, it will be well to explain the exact nature of the problem under consideration. The ideal, or "simple" pendulum of the mathematician consists of a heavy particle of no dimensions, connected with the centre of suspension by an inflexible string without weight; and, in order that its vibrations may be described in equal times, the arcs traversed must be very small, and the length of the pendulum must be invariable. Such a pendulum cannot of course exist in practice, but it is possible to calculate, for any actual pendulum, what would be the length of the simple pendulum, satisfying the above conditions, to which it corresponds. Thus, if $a\ b$ be the total length of a pendulum the period of whose oscillation is t, and $a\ c$ be the length of a simple pendulum that oscillates in the same time, $a\ c$ is the simple pendulum corresponding to $a\ b$. The point a is termed the centre of suspension, and c is the centre of oscillation. The one necessary and sufficient condition to be satisfied by the compensated pendulum is that this length $a\ c$ remain invariable.

The earliest design of pendulum of the first-class is the well-known "gridiron" of Harrison. It was invented in 1722, by Graham, but he soon abandoned this form in favour of mercury compensation, and the system was perfected by Harrison. From the diagram, which exhibits all the essential features, it is seen to consist of a heavy bob suspended by nine vertical rods, five of these being of steel and four of brass. The principle of its action may be easily demonstrated by means of two simple experiments.

Above this trough containing spirits of wine, two rods, one of steel and the other of zinc (used instead of brass in order to increase the effect) are supported horizontally; their left-hand extremities are fixed, and the right-hand ends actuate two fingers, at present pointing in the same direction. On igniting the spirit, the two rods will expand, but to different degrees, and this fact is shown by the pointers gradually separating from each other.

Now, vary the experiment. Take rods of the same two materials, but let their lengths be inversely proportional to their expansibilities, that is, if the length of steel is 1, the length of zinc will be 0·4. Connect their extremities at A, and support them over a trough, the end, B, of the steel rod being rigidly fixed, while a light pointer is attached to C, the free end of the zinc. Since A C is to A B as the expansion of A B is to the expansion of A C, it follows that the expansion of A C towards the right will move the point, C, just as much in that direction as the entire rod, A C, is moved towards A through the expansion of A B. Hence the point, C, will remain fixed, a fact which is made evident by the steadiness of the pointer.

A pendulum required to vibrate seconds must be of such a length as to make the distance between the centres of suspension and oscillation 39·14 in.; and it must further satisfy the condition here indicated, namely, the expansion of steel downwards must equal that of brass upwards. The coefficients of expansion of steel and brass are respectively 0·0000124 and 0·0000188 per 1° Centigrade, and it can easily be shown that the smallest number of rods that can satisfy this condition, keeping the pendulum symmetrical, is 9.* The arrangement of the rods and the mode in which they effect the required object is evident from the diagram. The two outer steel rods are firmly pinned at right angles to the upper brass cross-piece, but they are only held loosely by the pins in the lowest cross-bar. This carries two brass rods expanding upwards, and each pair is loosely held by pins in the same way. The innermost steel rod hangs from a pin at its upper end, passes freely through the lower cross-pieces, and supports the pendulum bob by a nut at its extremity.

The necessity for so many rods has always been regarded as a serious objection to this form of pendulum, and many attempts have been made to avoid the difficulty. Troughton suggested a very elegant arrangement, in which the four brass rods are replaced by two brass tubes, the five steel rods being joined in a manner corresponding to that above indicated. The bulk of the pendulum rod is thus diminished to a tube 0·6 in. in diameter, an important point, since the centre of oscillation is thereby lowered, and a shorter pendulum can be employed. As already noticed, zinc has a much higher expansibility than brass, and attention was, therefore, directed towards the employment of this metal. By increasing the length of the pendulum, and placing the bob some distance above the lower end of the pendulum, as shown in the diagram on the wall, supported by a short cylinder of zinc, Berthoud† succeeded in obtaining sufficient compensation with only two brass rods and three of steel; and, even with a brass cylinder in place of the zinc, the compensation was at times found to be complete. This is a compact form of gridiron pendulum, but the excessive friction between the rods is a serious objection. Berthoud constructed them about 13 in. long, beating half seconds, and the centre of oscillation comes very near the centre of the bob if the proportions given in the diagram are observed.

Reid, Tiede, Jacob, Ward, Dent, and others invented pendulums in which zinc and steel are employed in conjunction; and in an interesting arrangement suggested long ago by Robert, zinc is associated with platinum as being at the opposite end of the scale of expansibility. The form adopted by Jacob‡ is shown in the diagram, and it is worthy of notice on account of its extreme facility

* For, let n be the number of downward expanding steel rods, and n' the number of upward expanding brass rods, and assume them to be approximately of equal lengths; we have

$$\frac{n}{n'} = \frac{\text{co-efficient of expansion of brass}}{\text{,, \quad ,, \quad steel}} = \frac{0·0000188}{0·0000124} = \frac{3}{2}$$

very nearly. There are then 5 rods required theoretically, and 4 additional ones are needed in practice, to give rigidity and symmetry to the pendulum.

† Moinet "Traité Général d'Horlogerie," ii., 412.

‡ Exposition Universelle. Saunier, p. 92.

of adjustment. The centre rod is of steel, and terminates in a screw bearing a locking-nut, which supports the rectangular zinc frame. A screw thread is cut on the upper portion of this, and a nut on it supports the frame that carries the bob. Assuming the pendulum to be under or over-compensated, it will only be necessary to elevate the upper screw and depress the lower one, or *vice versâ*, and the effective length of the zinc will thus be altered as required. The expansion of zinc being more than double that of steel, a single zinc rod less than the length of the pendulum will suffice for the compensation.

The only other combination of these two metals that need be specially referred to is the pendulum employed by Messrs. Dent and Co., for their astronomical clocks, in which the bob is of lead, and the steel and zinc are two concentric tubes, the rod also being of steel. This system is shown in the diagram. A zinc tube resting on the rating nut supports, at its upper end, a steel tube by which it is enclosed; to the lower end of the steel is fixed, by its centre, the lead bob covered with a brass jacket. Holes are drilled through the steel and zinc tubes in such a manner that each portion of the pendulum is equally influenced by thermometric variation.

The pendulum by M. Robert, above referred to, is shown in this diagram, copied from the "Bulletin de la Societé d'Encouragement" (xxviii. 56) for 1829. A light platinum tube passes through a zinc bob, and terminates in a steel screw, which carries the rating nut. The bob extends to half the height of the rod, and its upward expansion is sufficient to neutralise the downward expansion of this latter.

Numerous other combinations of two or more substances have been suggested from time to time, but detailed reference to them is unnecessary, since the principle of all is identical. J. L. Smith* employed a vulcanite tube surrounding the lower extremity of a steel rod, in a manner somewhat analogous to Berthoud's pendulum, only that the tube passed up within the (copper) bob; Ley† used zinc and glass similarly arranged; and Callaud‡ proposed the combination shown in the diagram, in which steel, brass, and platinum (wire) are used. The brass tube resting on the timing nut supports a plate at its upper end, through which pass two screws attached to the extremities of a platinum wire. This, passing round a groove in the pendulum bob, raises it as the brass tube expands, and the adjustment for compensation somewhat resembles that of Jacob's pendulum. Benzenberg's pendulum, as modified by Kater,§ consists of a lead tube traversed by an iron wire, the bob being suspended by two iron wires from the upper end of this tube. By employing deal and zinc, Kater succeeded in reducing the length of compensation metal so as to conceal it within the bob; and Baily, in his celebrated paper on "Compensation," proposed a cheap construction, in which the upward expansion of a cylindrical lead bob neutralised the downward expansion of a deal rod.

According to Short,‖ compensation by means of levers was suggested by Graham, but abandoned in favour of mercury. In the hands of Ellicott, it gave some very good results, and an excellent specimen of this form of pendulum may be seen in the hall of the London Institution. Its mode of action will be understood from two diagrams on the wall, which are taken from Reid.* The rod consists of a brass bar enclosed between two flat steel bars, but all three are free to expand independently downwards, being rigidly fixed at their upper ends. The bob is free to move on the rod, and is hollowed out in its centre, to receive the mechanism shown in the second figure. From this drawing it will be seen that the brass bar presses on a loose steel pin, which, by means of the intermediate brass piece, actuates two horizontal levers centred on the steel of the pendulum rod. The bob is supported at the extremities of these levers, and, since the expansion of brass is greater than that of steel, it will be evident that any change of temperature will thus cause the bob to rise or fall; by varying the points at which the bob is supported, the extent of this motion may be altered, and thus the compensation adjusted.

In pendulums of more modern construction, the three rods are separate, having the appearance of a gridiron, with steel in the middle and brass or copper on either side. A horizontal right and left-handed screw is held in a stud on the middle rod, and engages in studs in the external rods, and thus, by a slight rotation in either direction, the length of the acting arm of the lever, and therefore the degree of compensation, can be varied. A pendulum working on the lever principle was patented by the celebrated engineer, Richard Roberts, of Manchester†, but it does not seem to have been employed.

Lastly, an ingenious contrivance by Tremeschini‡ should be mentioned, as it acts on an entirely novel principle, although levers are used. It is shown in side elevation in the diagram, and its action will be understood by a reference to this sketch [on black board]. The rod consists of two detached bars of copper and steel, fixed at their upper ends, and bent at an angle backwards, so that the centre of gravity of the bob, which is supported on a horizontal arm, may be directly below the centre of suspension. This arm is pivoted at the extremity of the copper rod, the steel being bent a second time, and pivoted at a point a few inches in advance, while the bob can be moved horizontally by means of a nut. Assume the arm to be horizontal at a certain temperature. If the pendulum become hotter the copper and steel rods will expand, but in different proportions, the expansions being nearly in the ratio of 3 to 2. The arm, A B, will, therefore, take the position A′ B′, and on still further heating it will move to A″ B″. The inventor points out that on the horizontal line, A B C, there is one point through which all these lines pass, and that, on making the centre of gravity of the bob coincide with this point, the pendulum will be unaffected by heat and cold. The problem is, however, not so simple as here stated, for the pivot of the steel rod will move almost in a vertical direction, whereas that of the copper will expand

* "Comptes Rendus," lxxxiii. 202.
† "Horological Journal," xix (1877) p. 74.
‡ "Revue Chronométrique," iv. 626.
§ Kater and Lardner's "Mechanics," p. 266.
‖ "Phil. Trans.," 1752.

* "Treatise on Clock and Watchmaking" (1826) page 367.
† Specification 12,207, A.D. 1848.
‡ "Revue Chronométrique" viii. 95, and Patent No. 2,671, A.D., 1873.

outwards, and, assuming these pivots to be accurately fitted, the co-efficient of expansion of the arm itself must be proportioned to that of the rods, if the rods are to continue in the same relative positions. Calculation or a geometrical construction shows that, employing the proportions of the diagram (which is copied from a description by the inventor), the short horizontal piece would be required to have a co-efficient of expansion about 2·2 times that of copper, in order that the pins might always be equally free from strain, and the position of the bob in a vertical direction remain unaltered. It is hardly necessary to observe that a metal with so high a co-efficient of dilatation does not exist; but the geometrical principle is interesting, and advantage may some day be taken of it.

The forms of pendulum that are included in Class III. are almost as numerous as those which have the gridiron for a type. They are all based on the following fact. If, at a certain mean temperature, strips of two metals of different expansibilities—such as steel and brass—are rigidly united in the form of a straight rule, then an increase of temperature will cause the pair to bend with the more expansive (brass) outwards, and, on a fall of temperature, the converse will be the case. The reason for this fact is so obvious as hardly to require explanation. Although both metals expand, the steel, relatively to the brass, will contract in heat, and this can be illustrated by a simple experiment analogous to the last. A compound strip of steel and zinc is here fixed rigidly at one end over the trough, and a tongue projecting from the free end actuates a bent lever. This lever terminates in a long vertical pointer, and any motion of the strip in a vertical plane will thus be indicated by a movement of the pointer to the right or left. Steel is above, and on applying heat, the pointer moves to the left, indicating a motion upwards, and the converse is the case on cooling the strip. Of course, a similar effect would be observed if the metal were curved; indeed, straight strips are rarely employed in practice.

Brass and steel are nearly always employed in conjunction, and the combination may be made available for compensation in three ways: (1) raising and lowering the entire pendulum, by being attached to the suspension spring or thread, which passes between two edges near together, a plan adopted by Destigny* for small clocks, and shown in this diagram; (2) moving one or more auxiliary weights to or from the centre of suspension, in the manner indicated in the next figure; (3) by moving the entire bob in a vertical direction, as is done in Cole's pendulum, also shown. It is strange that, while nearly every compensation balance involves the use of bi-metallic strips, the device is very rarely applied to pendulums, although the second mode of employing it seems, at any rate, to afford good means of effecting the final adjustment of the compensation. The great merit of the system is that the motion is continuous, and not step by step, as in the two classes previously considered.

A curious arrangement, involving the use of bi-metallic strips, was patented in 1840, by Dent,† and deserves mention. He proposed to communicate the impulse to the pendulum at its centre of percussion, and two arms projected from the escapement, placed below the pendulum, on either side of the bob for this purpose. Two U-shaped compensation strips were attached to the bob, and received the impulse from these arms; on heating, the pendulum lengthened, the strips moved outwards, and were therefore struck with greater rapidity, since the arc of vibration was diminished; thus the loss occasioned by the expansion of the rod was counteracted.

In 1855, Merceron showed, at the Paris Exhibition, a pendulum in which the effect of temperature was avoided by forming the rod of a series of bi-metallic strips arranged alternately, and the diagram shows the manner in which Ingold* proposed to carry out this principle; modifications were also suggested by Saunier.† It is only necessary to point out that the brass is on an equal number of concave and convex sides, and thus the position of the bob, which is supported at its centre, remains unchanged, since one bend will tend to close to the same distance as the next tends to open.

The only other application that remains to be noticed was proposed by the Astronomer-Royal, for effecting the final adjustment of the compensation, and adopted in the Greenwich sidereal clock.‡ Two small straight bi-metallic arms, carrying weights, are held friction-tight on the crutch axis, and, by varying their inclination, it is possible to alter the vertical distance through which their common centre of gravity is moved on a change of temperature. This motion is anticipated to produce the requisite change in the rate of the clock, but it has not yet been found necessary to bring it into action.

We now come to the fourth and last class of pendulums, those in which mercury is employed. Graham first advocated its use in 1722, and the pendulum has only undergone slight modifications since his day. The form ordinarily met with in regulator clocks consists of a steel rod, terminating in a stirrup of the same metal, which carries a glass cup of mercury. When the temperature rises, the steel becomes longer, but the volume of the mercury increases, and, since its expansion is greater than that of glass, its level rises, and there is thus a tendency to maintain the position of the centre of oscillation constant. Obviously, a certain volume will exactly suffice to maintain it stationary, and the pendulum will then be independent of temperature. There is some difficulty in introducing the mercury without carrying down bubbles of air, and M. Fenon recommends the use of a long glass funnel, reaching to the bottom of the vessel, for this purpose. Two principal objections have been urged against the mercury pendulum; the glass vessel, being a very poor conductor, makes the metal it contains change temperature much less rapidly than does the steel rod, and the compensating metal, mercury, is not necessarily at the same temperature as this rod. Several makers have attempted to avoid the first-mentioned difficulty by distributing the mercury through two or more vessels (the diagram represents

* Roret's "Manuel d'Horlogerie" (1850) p. 95.
† Specification No. 8,625, A.D. 1840.

* "Revue Chronométrique," iii., 83 and 131.
† "Revue Chronométrique," iii., 142.
‡ "Nature," xi., 433, and "Horological Journal," xvii., 26.

the arrangement proposed by Vissiere) but this practice increases the difficulties of adjustment. A more convenient method is to replace the glass by an iron vessel, and prolong the rod into the mercury; in this case it is also possible to expel air from the metal by boiling *in situ.* Laugier* made experiments with a view to ascertain the most convenient diameter of the vessel as compared with that of the rod (of iron), a proportion which of course is dependent on the specific heat and conductivity of the metals. He finds that the iron jar should be four times the diameter of the rod, and he further states that in pendulums of the first two classes the diameters of iron, copper, and zinc rods should be to each other in the proportion 100, 135, 109.

In comparing the several kinds of pendulums, it is to be observed, that most of the forms included in the first two classes are equally satisfactory for a change in the temperature of the entire length of the rod, or for only a portion of its length, but this is not the case with the third and fourth classes. Now, the temperature of a clock-case, with seconds pendulum, may vary as much as 3° or 4° Centigrade, and in such a case the mercury or bi-metallic compensation would not be brought into action, although the rod would certainly be lengthened. This is the principal reason urged against Graham's pendulum by the French makers. They prefer the gridiron, which is objected to in England, on account of the great number of contacts, and the consequent non-continuous action of the compensation (a criticism which also applies to lever pendulums), the expense of its construction, the weight of the upper portion of the pendulum, and the pressure on the upper ends of the compensating rods. Mercury is, however, being now gradually discarded in favour of the gridiron principle, as applied in such pendulums as that of Dent, which has often been found to give more uniform results than the mercury pendulum. But Sir W. Thomson,† who has studied the question of compensation in connection with his new design of astronomical clock, concludes that the use of steel rods is a mistake, as the pendulum rod should be formed of a substance having the least possible expansibility, such as glass or platinum. Mercury, having a high specific gravity and expansibility, should be the other in preference to lead, unless the capillary uncertainty of its surface is found to occasion irregularities in the rate. He is, therefore, applying to his tide-gauges pendulums formed entirely of glass and mercury, with rounded agate knife edges, and anticipates that the error will be found to be not more than one-tenth that usually observed, and he points out that, if these precautions are not sufficient, it will be necessary to enclose them in an air-tight case, at constant temperature. It is interesting to compare this latest form of compensation with that invented just 50 years ago by Robert, and shown in the diagram, which in great measure satisfied the conditions laid down by Sir W. Thomson.

Barometric Variations.

Let us now pass to the means adopted for counteracting the effects produced by variations in the atmospheric pressure. Baily, in his celebrated paper read before the Royal Astronomical Society in 1823, seems to have been the first who drew the attention of astronomers to this source of irregularity, and the researches of Bessel and Sabine threw much light on it. Dr. Robinson,* in 1833, proposed to attach two light barometer tubes, filled with mercury, on either side of the pendulum rod; the effect of which would be that whereas, on the barometer rising, the increased resistance due to the friction, &c., would tend to occasion a loss, the fact of a small quantity of mercury rising towards the centre of suspension, in consequence of the rise in the barometer, would neutralise this effect. The amount of the error that has to be corrected has been variously estimated by different observers at from 0·42″ to 0·23″ per 24 hours for each inch rise or fall of the barometer, but, as Baily pointed out, it depends on the arc of oscillation of the pendulum. For in a circular pendulum the period of the long arcs is slightly greater than that of the short arcs; if, therefore, at the normal pressure, the pendulum describe a given arc, any increase of pressure will oppose a greater resistance, and, the arc being slightly diminished, its period will be increased. A point must exist at which these two influences neutralise each other, and Baily calculated it to be 2°·45′, a result which has been confirmed by the experience of the Westminster clock, as this is found to show no variation to correspond to changes in the barometer. Experiments by Dr. Hipp†, at the Neuchatel Observatory, lead him to the conclusion that this effect of the air, however, is not a simple modification of the amplitude, and that the irregularities observed are caused by the escapement, suspension spring, &c., a view which is also held by Redier.‡ Several attempts have been made to avoid this source of error by enclosing the clock in an exhausted space, and Redier§ and Hutton‖ attempted to enlarge or contract the air space of the pendulum. Only two systems are in practical use, namely that proposed by the Astronomer Royal¶, and applied to the sidereal clock at Greenwich, and the very elegant arrangement adopted by Redier.**

In the former the active force of gravity is supplemented by that of a small permanent magnet, so arranged that its distance from the pendulum bob varies with every rise and fall of the barometer. All the essential features are exhibited in the diagram, from which it will be seen that the magnet is suspended from one extremity of a short balance beam, while the other end carries a pendant, terminating in a steel disc which floats on the surface of the mercury in a syphon barometer. Two bar magnets are fixed to the pendulum bob, at a mean distance of $3\frac{3}{4}$ inches from the magnet, and the short arm of the barometer has twice the diameter of the long arm, so that a fall of one inch moves the magnet half an inch farther from the magnets.

Redier adopted an extremely simple device, which he states to be perfectly efficacious. It can be applied to any pendulum, and is shown in the diagram adapted to the ordinary Graham form.

* "Comptes Rendus," xxv., 415.
† "Nature," vol. xi., page 229.

* "Memoirs of the Royal Astronomical Society," vol. v., p. 125.
† "Journal Suisse d'Horlogerie" ii. (1877), p. 85.
‡ "Revue Chronométrique" ix., 281.
§ "Revue Chronométrique" ix., 177.
‖ Patent No. 11,427, A.D. 1846.
¶ "Nature," vol. xi., p. 433.
** "Comptes Rendus" lxxxiii., 1174.

To a transverse bar the exhausted box of an aneroid barometer is fixed, and a weight is attached to the under side. If, now, the atmospheric pressure increase, the weight will be raised in consequence of the contraction of the box; and it is obvious that, when this weight is properly adjusted, its motion will so alter the position of the centre of oscillation as to counteract the loss or gain caused by barometric variations.

Compensation of Watches and Chronometers.

The problem to be solved in the case of a portable time-keeper differs essentially from that hitherto considered, for the invariable force of gravity is replaced by a balance-spring attached to the balance, and affected by any change of temperature. To picture an analogous instance in a clock, it would be necessary to conceive of its being raised from the earth to such a distance as to materially diminish the intensity of gravity. An increase of temperature of 1° Centigrade in a chronometer may be taken to correspond to a loss of about 11″ per 24 hours,* and, to effect a similar change in the rate of a clock in the manner contemplated, it would be necessary to raise it to a distance of no less than 567 yards, or nearly one third of a mile from the earth's surface. As has been seen above, a similar change of temperature would only alter the rate of a clock with a steel pendulum rod, to the extent of 0·53″.

Compensation, then, in the case of chronometers is the more necessary, and it is a matter of greater difficulty as so many circumstances have to be taken into account. These are principally expansion and variation in the tension of the balance spring; thickening of oil; expansion of balance. The resistance opposed by the air is without appreciable effect on the rate. As the main source of variation resides in the spring, it is an object to employ a material for its construction that is but slightly influenced by heat, for by so doing the amount of compensation necessary will be reduced, as well as all irregularities due to its imperfection. Attempts have been made to employ glass for this purpose with some success, as is proved by chronometers made by Dent, of which one is now to be seen in the South Kensington collection of apparatus. Although not justified by experience, the fear of breakage has prevented their general use.† Paillard gives a table showing the effect produced by substituting springs of various metals for the steel springs in an adjusted chronometer, from which it appears that, for a rise in temperature of 33° Centigrade, platinum gives a gain of two minutes, and palladium of 40 seconds, whereas all other metals give a greater or less loss; and he concludes by preferring an alloy of palladium. Iridio-platinum has also been recommended, but none of these have ever come into general use.

The compensation may be applied direct to the balance-spring, or it may be effected by varying the form of the balance itself.

* Delamarche and Ploix, "Comptes Rendus," xlviii., 241 (1859). —So regular is this change, that a chronometer may be used as a thermometer. For the instrument these authors experimented upon, the rate r and temperature t are correlated so that $r =$ 3 min. 33·5 sec.—11 t sec. See also some experiments by the Astronomer Royal, given in the Reports of the Juries (1862), and confirming these results.

† "Journal Suisse d'Horlogerie," i. 207, and ii. 49.

Many devices for altering the acting length of the spring have been introduced, and they were much in use in the early part of the present and the latter part of last century, but they have the grave objection of interfering with the isochronism of the spring, and have now been almost universally abandoned. It will, therefore, be unnecessary to do more than indicate their general arrangement, and the three figures on this diagram will suffice for that purpose.

The first* represents a mode of displacing the stud in which the outer extremity of the spring is fixed, but this can only be regarded as the very roughest approximation to an efficient compensation. The movement is brought about by fixing the stud to the end of a strip of a highly expansive metal, such as zinc, held by a screw at its other end to the plate of the watch. The exact length is determined by trial. In the second form† the arm carrying the curb pins is pivoted on to the index, and moved by a strip of metal which surrounds the top pivot of the balance; the acting length of the spring is thus modified, as in regulating the watch. The third figure represents the form adopted by Breguet‡ for compensating the cheaper class of watches. One curb pin is fixed in the index as usual, and the outer pin, being carried by a curved bi-metallic arm attached to the index, is moved towards the fixed pin on a rise of temperature, and from it in the converse case, thus varying the acting length of spring by altering the play allowed to it.

Some very careful experiments made by Dent in 1842§, as well as subsequent experiments by Rodanet‖, seem to show that the change in the tension of a balance-spring is exactly in inverse proportion to the change of temperature. Now, the inertia of the balance, that is, the resistance it opposes to being set in motion, is proportional to the square of a certain dimension, known as the radius of gyration, which corresponds to the distance between the centres of suspension and oscillation in a pendulum. Hence it follows that, assuming the above law of the tension of the balance-spring to be absolutely exact, for the period of vibration to be maintained constant this dimension must so vary that its square is always in inverse proportion to the temperature, for, in that case, its ratio to the tension of the balance-spring will be invariable. But we have here assumed that only the tension of the spring varies, whereas the changes in the consistency of oil are of such importance as to materially modify the above conclusion, and the other sources of error already enumerated have also to be taken into account; the problem thus becomes one of considerable complexity.

The absolute compensation of a chronometer may be divided into two parts. In the first, or primary compensation, the balance is so adjusted that the rate is the same at two extreme temperatures, say, 0° Centigrade and 30° Centigrade; and, in the second, such modifications are required as shall tend to cause the chronometer to maintain this rate at all other temperatures, for it is found that the simple com-

* Dansart. "Revue Chronométrique," iii. 282.

† Sandoz. "Revue Chronométrique," vii.. 109.

‡ See "Rees' Cyclopœdia," article "Compensation."

§ See pamphlet by Dent on "Errors of Chronometers," 1842.

‖ "Revue Chronométrique," i., 86

pensation balance, as used in the best watches, and in ordinary chronometers, does not suffice to effect that object.

Simple balances are of two kinds, and their forms have remained unchanged since they left the hands of Arnold and Earnshaw at the beginning of the century. Both are shown in this diagram. Their action depends on the principle, already illustrated by an experiment, that if two metallic strips of different expansibility are rigidly connected together, a change of temperature will cause them to change their radii of curvature. The amount of this change is, however, very slight, and the motion for a range of 100° Centigrade may be assumed to be represented approximately by the interval between these two arcs, which has been determined by calculation; a radius of 25 inches at 0° becoming about 24·6 at 100°. The first form consists of a straight steel bar, carrying a curved bi-metallic strip at either end, and in these are set a number of small gold screws. It will be observed that the rim is cut through at two points, so that the strips are free to move inwards and outwards through their entire length, except at the fixed ends. The balance being centred so that the whole is symmetrical, it will be seen that any change of temperature will cause the ends to move to or from the axis of rotation, and thus to modify the radius of gyration of the balance. This construction is usually applied to watches, whereas the use of the second is confined to chronometers. Its mode of action is precisely the same, but the screws are replaced by two weights, whose position on the strips may be varied. The compensation is effected in the first form by changing the position of one or more screws towards or from the free end of the strip to holes provided for this purpose, for by this means the distance through which each mass of metal is moved is varied, and a greater or less change is produced in the radius of gyration. In the chronometer balance the weight is moved along the strip, and fixed by a set screw. But it must be understood that the problem of compensation does not consist solely in determining the exact position to be occupied by the compensating weights, but it is necessary also to find the size and moment of inertia of these masses, having regard to the distribution of the matter of the other parts of the balance and the constitution of the bi-metallic strips.

M. Yvon Villarceau* states that the difficulties in the way of compensation are due solely to the imperfections of these strips, and he finds, as the result of an elaborate mathematical discussion of the question, that, for maximum efficiency, the ratio of the thickness of brass to steel should be 17 to 12, that is the inverse proportion of the square roots of their elasticities, and not in the simple inverse proportion of these elasticities as is implied in the ratio 2 to 1, often adopted.

Further, the researches of Caspari,† on the going of chronometers, lead him to conclude, as we should anticipate, that the strips should be made as thick as possible, the weight being no larger than is essential for effecting the compensation.

* "Annales de l'Observatoire de Paris," tom. vii. (Memoires, 1863), p. 1—160.
† "Comptes Rendus," tom. lxxxi. (1875), p. 1122.

Attempts have been made to ascertain the exact path taken by the weight of a compensation balance when the temperature varies. M. Rodanet* showed experimentally, with a strip of brass and steel in the proportion of 2 to 1, that the centre of each weight moves in a straight line, which passes more and more nearly through the balance-staff, according as the distance between this weight and the point of attachment of the strip is diminished. Some of his results are shown in this diagram, and they indicate that as the angular distance of the weight from the fixed point is diminished, the path of the weight approximates to a radius of the balance. It is right to observe, however, that the determination experimentally of the exact path of the weights is a question of considerable difficulty, and these results can only be regarded as approximate. M. Villarceau proposed a more delicate method of experiment than that adopted by Rodanet, but no results have hitherto been published.

It is a fact well known to chronometer makers that, if a balance, such as either of those already described, be adjusted so that the same rate is maintained at 0° Centigrade and 30° Centigrade, a gain will be observed in intermediate temperatures; or if adjusted for 15° and 30°, it will lose below 15° and above 30°. This error amounts to about 4 seconds in a range of 30° Centigrade; thus, if adjusted for two extreme temperatures (0° and 30°), the maximum gain will occur at the intermediate temperature (15°), and will amount to about 2 seconds. Very many balances have been designed with a view to avoid this source of irregularity, and some of these are shown in the diagrams, and will be presently described; but it will be well first to consider the error in some detail.

By drawing a series of concentric equidistant circles cutting the lines which, according to Rodanet's experiments, indicate the path of the compensating weight, it is at once seen that the parts of each line are not equal among themselves; and, further, that the ratio of the sections of one line, *a b*, for example, is not identical with that of the sections of any other line, *c d*. Assuming, then, that the distance travelled by the weight per degree remains constant, the figure shows that the relative rate of motion inwards, at different temperatures, depends on its position along the rim. Now, the ordinary adjustment of the compensation, at, say, 0° Centigrade and 30° Centigrade, only amounts to setting the mass in such a position that its total inward motion for a rise of 30° just neutralises all the various effects of heat above alluded to, and the relative rate of motion per 1° will depend on the distance between this mass and the fixed end. This distance is, of course, different for each chronometer, and it seems probable that the constants in Lieussou's formula, presently to be referred to, would be found to in part depend upon it.

But at no point along the rim of an ordinary balance is the rate of motion such as to maintain the rate of the chronometer constant for all temperatures. The motion inwards should be more rapid, as compared with that outwards, and it is generally admitted that the weights should approach the centre at a gradually increasing rate,

* "Revue Chronométrique," I., 86.

receding from it, therefore, with a gradually diminishing velocity; whereas, in the ordinary balance, the converse is the case.

It is not evident, without a little reflection, why the error is a gain at temperatures between those for which the adjustment has been made, and a loss at temperatures both above and below that range; but the figure will at once show that such is the case. Assume the chronometer to be adjusted for 15° and 30° Centigrade; take two axes of co-ordinates, and let points on the vertical axis indicate temperatures; through these points draw horizontal lines parallel to the other axis of co-ordinates. If distances are measured along the lines corresponding to 15° and 30°, to indicate the tension of the balance-spring, and a line be drawn through the points thus determined, the tension at any temperature will be ascertained, on the assumption that it varies uniformly. The motion of the weights, however, and therefore the moment of inertia, does not vary uniformly, and must be expressed by points on a curve of some such form as that shown in the figure.

Now, if the ratio of the tension to the moment of inertia were invariable, this latter would be determined for all temperatures by a straight line passing through the points on the curve at which it is made to correspond. The figure shows that, between these points, the tension is relatively in excess, causing a gain; whereas, beyond them on either side the converse is the case, and there is necessarily a loss.

The curve just discussed suggests a means of determining the manner in which the chronometer, as a whole, varies with the temperature. For, assume it to be accurately adjusted at 15° and 30°, and then maintain it, for periods of 24 hours each, successively at a series of different temperatures; the loss or gain due to the change will indicate the distance of the corresponding point on the curve to the right or left of the straight line. Representing now each second by, say, six inches on a large diagram, the observed rates may be plotted, and the curve obtained will at once indicate the gain or loss to be anticipated at any given temperature.

And a further extension of this principle suggests itself. The abscissæ of points on the line of tension represent forces, and the moment of inertia is also measured in the same terms. Hence, the interval between these two lines corresponds to a force dependent on temperature, and, so long as it can be kept in a constant proportion to the tension, the rate will be invariable. Now, a variation measured in seconds really indicates a change in the proportion subsisting between the two forces, and a number of carefully made observations, through a long range of temperature, might enable the mathematician to formulate the law governing the motion of the weights, and thus to determine their paths.

The method adopted by Mr. Hartnup, of the Liverpool Observatory, for tabulating the errors of chronometers, and that of Lieussou, amount to a simplification of this method, and they have been found of the greatest service in practice.

Lieussou,* in an elaborate paper describing observations on a large number of chronometers, concluded that if T be the mean between the two temperatures at which the chronometer is adjusted, and a the rate at this mean temperature, the rate, m, at any other temperature, t, may be represented by the formula :—

$$m = a + b\,x - c\,(T - t)^2.$$

where x indicates the age of the oil in days, and b and c two constants that vary with different chronometers. In a good instrument he finds the several terms to have the values, $T = 15°$ to $20°$; $c = 0{\cdot}02''$ as a maximum; $b =$ not more than $0{\cdot}01''$ per day; a will, of course, depend on the rating of the chronometer. According to these figures, an instrument that is initially set to lose five seconds a-day at the temperature T, will, at the end of three years, gain this same amount. Lieussou's formula was modified by Pagel, but Villarceau maintains that both forms are incomplete. He points out that a theorem, known to mathematicians as Taylor's, offers the only complete method of expressing the rate of a chronometer under varying conditions, and this suggestion has been practically examined at sea by Lieut. de Magnac,* with very satisfactory results, although the requisite calculations are extremely involved.

Hartnup's† method differs materially from that of the French authorities, as his formula only contains one variable term, involving the square of the difference of temperature. Using Lieussou's symbols, the expression becomes

$$m = a + c\,(T - t)^2.$$

A method very generally adopted for diminishing the error of the ordinary balance consists in adjusting the spring so as not to be absolutely isochronous, but to occasion a slight gain in the short arcs, thus setting one source of error to counteract another. The instrument being adjusted at 15° and 30°, a fall below the lower point will occasion thickening of oil and therefore short arcs, when the accelerating effect of the spring will come into play. But any departure from true isochronism is by many regarded with suspicion, although Phillips,‡ a high authority on the spiral spring, advocates the above practice.

Bearing in mind that the object of every auxiliary or modification of the ordinary balance is to make the radius of gyration diminish more rapidly with a rise of temperature than is the case with an ordinary balance, and increase more slowly on lowering the temperature, a very few words will suffice to explain the various forms shown in this diagram; modifications of the circular balance, which I have endeavoured to select as typical. The first, invented by Le Roy§ in 1766, as a means of avoiding the irregularities he observed with the bi-metallic strips, is a plain brass balance with uncut rim, and the compensation is entirely effected by the motion of the mercury in two glass thermometer tubes placed radially, the bulbs being filled with alcohol; this was the earliest form in which the motion took place in a straight line directed towards the centre. No. 2 is one form of Molyneux's auxiliary, patented in 1840. When the strip in its inward motion reaches a certain position, it

* See "Comptes Rendus," xxxvi., 1853, p. 894.

* "Recherches sur l'emploi des Chronomètres a la mer," 1874.
† "Horological Journal," xx., p. 134.
‡ "Revue Chronométrique," v., 290.
§ "Revue Chronométrique," iv., 422.

comes in contact with a second smaller weight, and the effective movement is thus a product of the motion of both weights; the adjustment being made for low temperatures is thus approximately correct for higher. In Poole's balance, No. 3, a similar result is secured by checking the movement outwards; the adjustment for this case must be made at the higher temperature. No. 4 shows Jacob's* balance, where a second small balance is fixed within the first, and banked so as only to act in heat; it can be rotated on the balance-staff, and thus, while the principle is nearly the same as that of Molyneux, it offers a greater range of adjustment.

Hutton and Breguet† (J. H.) have patented arrangements for correcting the error in the primary compensation, by modifying the resistance opposed by the air to the movement of the balance, which is enclosed for this purpose in a confined space; but as no such method is ever employed in practice, it will suffice to merely refer to them.

A curious device, due to a Dutch chronometer-maker, Hohwü, is represented at No. 5 diagram. Although quite impracticable in the form shown, it is theoretically preferable to those previously described, and I have therefore included it in the selection. A bi-metallic helix is adapted near the extremity of the ordinary rim, and carries a collar, in which a weight is screwed, so as to be adjustable. The motion of this weight with a change of temperature, is the resultant of that due to the rim and helix, and its effectiveness depends on the distance between the middle of the helix and the centre of gravity of the weight; this, of course, is variable.

Although carried out in a very different manner, the compensation weights patented in 1843 by Lund‡, and that more recently proposed by Vissiere,§ and shown at No. 6 involve a similar principle. Lund's weights are too complicated for brief description, but it may be mentioned that they appear to be far less sensitive to centrifugal force than do those of Vissiere. Without entering into the details of construction of the latter, it will suffice to say that the weight is carried on a small divided bi-metallic ring attached by an arm to a block that can be set in any position along the bi-metallic rim of the balance. The weight can be moved along the ring for adjustment, and the entire system forming the weight can be rotated about the centre of this ring. It is evident that the motion of the weight is the resultant of that due to the two bi-metallic strips, and the adjustment consists in so co-ordinating these, that the inward motion is increased, and the outward diminished.

Another balance of this class that remains to be noticed, namely Loseby's,‖ involves the use of mercury. This is contained in two thermometers curved towards the centre of the balance, and, some years ago satisfactory results were secured by its inventor; but mercury and glass are very objectionable, and are now never employed.

A balance acting on an entirely different principle to any of the above has been recently invented by Woerd* in America. It is shown at No. 7, and is characterised by the total absence of the ordinary bi-metallic strip. As seen in the diagram, this is replaced by a band of steel, which is cut near the junctions with the diametral bar; saw-like indentations extend across the entire band, and these spaces are filled in with a highly expansive metal. The uncut portion of the steel, carrying screws, is thus caused to move to or from the centre by an amount depending on the number of teeth; the inventor, moreover, claims that its amount of inward motion gradually increases in accordance with the requirements of theory—in other words, that the tension of the spring and moment of inertia of the balance bear the same ratio to each other in all temperatures—but it is not evident why such should be the case.

Finally, No. 8 represents a modification of the ordinary balance that has just been suggested by Saunier.† The idea seems well worth carrying out, at any rate, on an experimental balance, and he expresses a hope that some watchmaker will make such a trial. The two halves of the diametral arm, instead of forming parts of a straight steel bar, are semicircular bi-metallic pieces, with the brass on the inside face. They are so placed that changes of temperature increase the movements of the compensation weights both in heat and cold. It seems certain, from a consideration of the combination of movements, that the effect of such an arrangement will be to produce a motion of the weights more directly towards the centre in heat, and less so in cold, thus materially reducing the middle temperature error. With care, the rigidity would be equal to that of the ordinary form, the difficulty of construction need not be great, and all the adjustments would be unaltered.

The impossibility of securing perfect compensation with the ordinary balance induced many attempts to be made to carry out the principle of rectilineal compensation, as illustrated by Le Roy's mercury balance. Hardy proposed to support two weights at the extremities of a flat bi-metallic strip, and this system was elaborated by Dent, and is the foundation of some of the more recent forms of balance.

The rectilineal movement is usually brought about by joining the two metals, so that the plane between them is at right angles to the balance-staff instead of parallel, as in the ordinary construction; the manner in which this tends to produce the required motion will be evident from a figure. The balance being adjusted for a mean temperature, any application of heat will cause the strip to bend upwards, since brass is below, and the converse will be the case in cold. Now, the amount of the motion to or from the centre is determined by drawing a perpendicular from the centre of gravity of the weight, which is carried by the upright, to the horizontal; and, by a well-known geometrical principle, this is less with a given motion downwards than for the same motion upwards. Dent's balance on this system,‡ known as the "staple balance," is shown at A. Its action will be very easily understood by a comparison of this figure with that just discussed. The application of heat will cause

* "Exposition Universelle" (1867), by Saunier, p. 92.
† Patents, Nos. 11,427 (1846), and 819 (1860).
‡ Patent No. 9,969, A.D. 1843.
§ "Saunier's Modern Horology," Art. 1360.
‖ Patent No. 1011, A.D. 1852.

* "Horological Journal," xxi., pp. 22 and 82.
† "Revue Chronométrique," x., p. 236.
‡ Patent No. 9,302 (1842).

the two staples to open out, since they are formed of the usual metals, brass and steel, and the weight will thus be raised, the compensation due to the main arm taking place at the same time. The result will be that the movement inwards is still further increased, as compared with that outwards; the ratio subsisting between the two must be varied by a change of the length or thickness of the staples. Some excellent chronometers are fitted with this balance, but it is difficult of construction, not easily poised, and liable to be affected by centrifugal force; Hartnup, therefore, of the Liverpool Observatory, proposed the form shown at B, and it was very successful in the hands of Shepherd, of that town. Its mode of action is not so evident as is that of Dent's; but a few words of explanation must suffice. The entire balance is formed of bi-metallic strips. In the central bar, brass is uppermost, but in the other two straight bars, steel. The segments forming the rim are of steel and brass, with their junction inclined at an angle of about 45° to the plane of the balance. The movement of the weight is thus a resultant of three motions, as will be better understood from the explanatory figure, in which only one-half is shown, for simplicity. The downward motion of the inner arm, *a*, increases the space through which the extremity of *b* travels by one-half, and the sloping segment imparts a skew motion to the weight, the amount of which depends on its position along the rim. The balance, however, is difficult of construction, and has not been successful with other makers.

This skew principle is also taken advantage of in Kullberg's balance, of which there are two or three varieties. C represents what he terms the low-rim balance. The centre bar is formed of brass and steel, the former uppermost. Two semicircular bi-metallic rims, whose section is shown in a separate sketch, are attached at opposite ends; they are made of considerable thickness, in order to bring the weights near the extremities.

Another balance of Kullberg's design, known as the flat-rim balance, has given excellent results, but is, I believe, now rarely or never used. It is circular in form, and the rim is a flat bi-metallic strip of the usual metals.

The last balance I shall refer to is that of Winnerl,* shown in plan and elevation at D and E, which has been recently invented. Three arms are employed, as in Hartnup's, but the central one is entirely of steel, and therefore remains flat in all temperatures. Bi-metallic strips of brass and steel, in the proportion recommended by Villarceau (0·43 mm. to 0·32 mm.), are attached to its ends, and these carry at their extremities inclined supports, on which conical platinum weights are screwed. The exact inclination of the arms must be adjusted for each make of chronometer and balance-spring. The adjustment is said to be extremely simple, and not to involve the removal of the balance from the instrument. The rates at two extremes are first brought into accordance by raising or lowering the weights, and then, for an increase at a mean temperature, the inclination of the support is diminished, and conversely with a loss. The timing screws are carried on a separate arm. Caspari* has discussed the efficiency of this balance, and concludes that it is competent to secure a perfect compensation, and does not interfere with the isochronism of the spring. He has further ascertained that the motion of the weight is the resultant of two motions, one proportional to the temperature and the other to the square of the temperature.

Although this seems to offer some advantages, it cannot be regarded as entirely satisfactory; for there is a great mass of metal at the centre, and the poising can never be as easy as in a balance of circular form. Kullberg has, moreover, pointed out that the use of screws for joining the bars is a grave objection.

The consideration of these few specimens, selected from the vast number of balances that have been proposed as means of securing an exact measure of time, shows that there are still several points far from being satisfactorily solved.

One point that cannot fail to be noticed is, that the adjusting of a chronometer, even when performed by the very best workmen, should require almost as many trials, and extend over as long a period, as it did in the days of Arnold and Earnshaw. Surely it is not unreasonable to expect that some of the ingenuity and skill that are devoted to the designing of auxiliaries might be expended in devising some more expeditious means of adjusting the primary compensation, and thus both reduce the cost of production of high-class work and diminish the risk of straining the balance-spring or damaging the mechanism, which no amount of care can always avoid. It does certainly appear remarkable, when labour is being diminished as much as possible in all the mechanical arts, that chronometer makers should be so far behindhand in this matter.

Another point that is worthy of notice, illustrated in a marked manner by the annual reports of chronometer trials at Greenwich, is the fact that no one form of balance has succeeded in establishing itself as invariably better than others; and even balances that are known to be among the best often figure low in the list. The frequency with which this is to be noticed is hardly explicable, unless we allow that circumstances influence the rate which are beyond the control of any workman, and that, when the performance of a chronometer is exceptionally good, the path of the compensating weights happens to accord with the several influences by which the movement of the balance is modified. The composition of the brass, the fineness of steel, degree of hammering, smoothness of acting surfaces, play of pivots, constrained molecular state of metals employed, and, above all, the nature of the oil—all these points may be perfectly satisfactory for compensation up to a certain limit, but beyond that each may have an infinitesimal effect which cannot be isolated or neutralised; and thus a balance whose compensation is perfect in one instrument may not give satisfaction in another, although made by the same workman.

In astronomy—that most exact of all the sciences—it is impossible to avoid even errors of observation, or differences between the actual time of a phenomenon and the period at which it is appreciated by the senses, except by a mathematical device

* "Horological Journal," xx., p. 32.

* "Comptes Rendus," lxxxii., 891.

involving probabilities, such as the method of least squares; it is not unreasonable to conclude, therefore, that a point must be reached at which the errors of every machine that is the result of human skill must be neutralised in some similar manner; and the tabulation of chronometer errors is a case in point.

The remark of Sir John Herschel* with regard to astronomical instruments is peculiarly applicable to chronometers, where so many actions require to be co-ordinated; and it might be remembered with advantage by many who introduce novel balances. "Human hands or machines," he says, "never formed a circle, drew a straight line, or erected a perpendicular, nor ever placed an instrument in perfect adjustment, unless accidentally, and then only during an instant of time."

The variation that every auxiliary is designed to correct amounts to only the $\frac{1}{648000}$th part of the period measured for each degree (Centigrade) change of temperature, and this comes very near the limit of sensibility of our best chemical balances, and is even almost comparable with Whitworth's wonderful machines for measuring lengths, &c.; instruments that are characterised by great simplicity, and subject to exceptionally few interfering causes. On the other hand, it must be admitted that the remarkable uniformity observed in the error of all chronometers with balances of the ordinary construction, tends to prove that the above-mentioned influences are of secondary importance; but they certainly do stand in the way of absolute perfection. It becomes a question, then, whether a recognised and comparatively large error, that can be allowed for, is to be preferred, or a so-called perfect compensation, that we feel convinced can never be attained except by accident, and is liable to be destroyed by the rough motion to which a chronometer at sea is always subject. No one would hesitate to select the former. Recent improvements in the pendulum have tended as much towards reducing the cost of construction as to increasing the efficiency, and it would be well if chronometer-makers would follow this example. What is now wanted, as already observed, is a means of materially diminishing the time required for adjustment and poising, and, consequently, reducing the cost; and the inventor of a really efficient and practicable method might rely on benefiting both himself and the trade generally. Too much stress cannot be laid on the necessity of solidity of construction, which is so sadly wanting in a vast number of the improvements that have been proposed; subject to these conditions, any invention that tends to diminish the middle temperature error should be welcomed, but such reduction is not worth having at the sacrifice of solidity.

The Astronomer-Royal, some years ago, pointed out that the chronometers received at Greenwich were very generally found to be unsatisfactory as regards the final adjustment of the compensation, and he, at the same time, suggested the best method that has been hitherto invented for facilitating it. It will be at once understood from the figure. Two small weights are carried at the end of an arm held by friction on the balance-staff, at the extremities of two light steel springs, and these weights are always in contact with the rim. By turning the arm to the right or left, the space through which they move is altered, since each point of the rim moves inwards through a different distance; the effect is thus the same as if the mass of the compensating weights were modified, and the poising of the balance is not disturbed. This appendage must not be regarded as in any sense an auxiliary; it is merely intended to serve the above-mentioned purpose, and is stated to be so easy of application, that the final adjustment is now often made at the Observatory.

Very little need be said as to the effect of barometric variations on the rates of chronometers. The question was studied by Jurgensen,* and he concludes that their influence is almost inappreciable, absolutely vanishing when the balance-spring is so adjusted that a reduction of the arc of vibration by 150° corresponds to a gain of 5 or 6 seconds per day. More recently, Villarceau† has calculated that, if the resistance opposed by the air to the motion of the balance varies as the square of the velocity, it has no appreciable effect, and this has been confirmed by observation.

In concluding, it may be noticed that no less than five of the physical properties of matter must be taken into account in designing an arrangement for compensation. These are:—Dilatation or expansion by heat; conduction or the power of transmitting heat from a colder to a hotter portion; specific heat, as on it depends the rapidity with which the pendulum (or balance) assumes the temperature of the surrounding medium; density, or the weight of a unit of mass; and elasticity at varying temperatures, especially in the construction of balances.

While theory is always a valuable guide to the practical observer, a question of such delicacy as the absolute adjustment of a chronometer must be solved by experiment; for, as we have already shown, a motion of the weights towards the centre, such that the square of the radius of gyration is inversely proportional to the temperature, will only suffice to maintain the rate uniform on the assumption that the tension of the spring is the sole variable, varying in inverse proportion to the temperature. But we also have changes occurring in the consistency of oil, diameter of balance, motive force, &c., and these cannot be regarded as having precisely the same effects in different cases. It necessarily follows that no balance can exist that is universally applicable, and the only balance capable of such absolute adjustment would be one in which the ratio of the movements per degree could be altered at will throughout the entire range of temperature between any two given points, and even then the effects of oil, &c., would, in all probability, alter in time. Such a balance has yet to be invented, and, until one exists that satisfies both the demands of theory and practice, it is far preferable to resort to the method already referred to, of tabulating errors, after having carefully adjusted any balance of simple construction, that can be depended upon to behave always in the same manner when under identical conditions.

* "Outlines of Astronomy," Eleventh Edition, p. 80.

* L. U. Jurgensen, "Exacte Mesure du Temps," 1838, p. 200.
† "Revue Chronométrique," ix., 183, and "Comptes Rendus," lxxxii., p. 697.

It only remains for me to express my thanks to Mr. Glasgow, Vice-president of the Horological Institute, for valuable information, and for his kindness in lending me, for exhibition this evening, the interesting collection of compensation balances that lies on the table.

DISCUSSION.

The Chairman, in inviting remarks, said that so elaborate an account of what had been so far done in the art of clock-making as had been given in the paper would be serviceable, should it serve no better purpose than to prevent persons "re-inventing," so to speak, what had been already invented, and thereby wasting valuable time.

Mr. Hale thought Mr. Rigg had not dealt sufficiently with that part of his programme which referred to watches. Certainly the paper dealt with descriptions of mechanism, which for nicety and exactness of construction were equal to anything invented. The statement that glass had been used in the construction of springs for chronometers had surprised him, as had also, to some extent, the assertion that wooden pendulums would not vary, though he could quite understand that a thoroughly dried piece of wood would be less subject to variations in temperature than many other substances. In these matters there was clearly nothing like perfection arrived at yet. Though sufficient accuracy had been arrived at for timepieces for ordinary and domestic use, it was necessary to ensure greater correctness for scientific purposes.

Mr. Watts said wooden pendulum rods were generally in use for turret and church clocks, and also in regulators.

Mr. Liggins concurred in that statement, and he had himself thought that if wooden pendulums were good for church clocks, they might usefully be adopted for bracket clocks. He had accordingly altered a very old family clock of that description, and of the best London make, by substituting a wooden for a brass pendulum, with very decided advantage. It might possibly be worth while to make a similar alteration generally; brass, being a cheaper and a prettier material, having probably been used by the makers of bracket clocks without consideration.

Mr. Webster never used anything but wood when he could help it for railway, church, or turret clocks. No doubt all were agreed that the weights should approach the centre in a greater ratio, of course, than they receded from it, but, strange to say, it should be the contrary theoretically—in practice it should be so, but in theory it should be the reverse. Why was that so?

Mr. Rigg could not explain why the theory should be the reverse of the practice in the matter.

Mr. Liggins pointed out that if the weights were moved an inch upwards, the motion would be faster than if it were lowered, and so with regard to the balance, if in expanding outwards the radius of gyration were moved a certain distance outwards by deprivation of heat, a slower motion would result than if it were moved outwards by heat; but they were all agreed that in practice it should be the reverse, as Hartnup and others had discovered.

Mr. Coffin considered that one of the advantages in the use of wood for pendulums might be that, in a fall of temperature, when the rod would be shortened, the hygroscopic property of the wood would come into play, which would tend to lengthen it, and so cause a natural compensation by the thermometric and hygroscopic properties of the wood acting in opposite directions. In some climates that certainly might be the case, though in others they would work together, when the effect would be to increase the error.

Mr. Pearsall had been informed by Mr. Dent of some experiments he had made, the result of which seemed to show that there was no substance in nature so truly elastic as glass, and that, in short, it was the most perfect material for these purposes with which he was acquainted. In a chronometer Dent had constructed as an experiment, the glass had been considered too delicate, but he had offered it to the Government, and it was taken on board the *Excellent* to see how far the rate would be interfered with by the conditions at sea. Unfortunately, it was allowed to fall before it could be tried, as intended, by being placed on the gun-carriages both in single and broadside discharges. After the smash, the chronometer was sent back to London, where it was found that everything had been broken except the glass spring, which remained intact. That would show what a really serviceable material glass was for the purpose. One reason why the best efforts of the most skilful workmen were nullified was the power of metals to absorb and give off gases. He was not aware of the degree in which gases were so absorbed and given off by metals, but, certainly, the fact that they did so to a greater extent in one temperature than in another should be taken into consideration in the construction of such delicate mechanism. He would be a very bold person who should say that the effect of ozone, to mention one among the gases, was exactly the same as that of ordinary oxygen, and it might be, in fact, an interfering substance. A few years ago, the effects of both light and heat, now shown by the radiometer, were not thought of. The motion of the air might be greatly affected by the power of the metals to absorb and give off gases. There was also the question of their tendency to combine, because it was well known in chemistry that many substances would cling together, but would never form perfect compounds.

Mr. Fraser said that a wooden pendulum with the leaden bob had been affixed to a regulator clock in Dent's shop, and was keeping excellent time. It was a very simple form of pendulum, and might be made very economically.

Dr. Mann bore testimony to that form of pendulum. He had one himself in Natal, with simply a rod of varnished wood supporting a cylindrical bob of lead. It was of course subjected there to great and rapid changes in the atmospheric pressure and to diversities of heat, but it worked excellently for many years. Subsequently it was replaced by one of Frodsham's best steel pendulums, and though there was some improvement, it was much slighter than might have been expected. In short, it was about as good a pendulum as could be conceived.

Mr. Killick, referring to the Saunier's balance shown on the diagram, said he had one now in his possession made 18 years ago. That balance had not yet been given a trial, and he would be happy to show it to any gentleman who would like to see it.

Mr. Crisp had had a balance made 25 years ago, like the Saunier balance, shown on the diagram, and, with regard to its giving superior results, it showed precisely the same error in the middle temperatures as the ordinary balance; there was no improvement at all. Whatever it might do with the addition of the laminæ he could not say, but he thought it would be neither better nor worse. With regard to oxidation, it was well-known that if the slightest oxidation attacked the balance-spring, it would gradually lose its elasticity, and would ultimately break. He had been much amused by the remarks made about glass springs, and could only ask why, if they had been so successful, they were not made. A specimen had been exhibited at the South Kensington Museum during the last two years, and it was so long there was scarcely any action in it at all;

while, if the spring were of a proper length, the vibration of the balance would break it to pieces. The late Mr. Charles Frodsham had tried one, but it never gave any satisfactory results. If glass had been found so successful 50 years ago, why had its use not been continued? With regard to the experiment on board the *Excellent*, the balance spring might have been saved by a mere accident, and it could be no test at all events as to its maintaining any superior rate. It was a well-known fact to chronometer-makers, that the moment a spring was touched with rust, it was condemned entirely. He had had several of the Astronomer Royal's pieces, and had found that the great difficulty with them was to keep the balance perfectly true; it became affected by the balance not been mathematically true.

Mr. Coffin said, in reference to the subject of glass springs, that three or four years ago, on the introduction of toughened glass, he made some experiments with it for a specific industrial purpose, and came to the conclusion that all such kinds of glass were continually undergoing a spontaneous molecular change, which would render tempered glass unfit for such purposes as had been mentioned.

M. Tripplin stated that a balance similar to that of the American Woerd, had been experimented with a year before by M. Adrien Phillipe, of Geneva.

Mr. Blackie doubted the value of the paper. Neither the subjects of isochronism, nor of expansion and contraction, had been elucidated, but the paper merely contained what could have been gathered from books. It was the work of a man of theory, not of a practical man.

Mr. Poole totally disagreed with the last speaker. Considering the short time at Mr. Rigg's disposal, he had dealt with his subject in a masterly way. Very few practical men had the power of expressing themselves at all, and it was almost necessary, therefore, to fall back upon a man who might to some extent be called theoretical, in order to place something like lucid views before the public. Being a practical man himself, he would say no more.

Mr. Liggins thought it ought not to go forth that the only persons to be enlightened upon the subjects of discussion were those immediately connected with them. The Society of Arts comprised gentlemen in every science and every manufacture, and they should all try to learn as much as possible of each other's work. The paper would be read with interest by many who would be glad to know what was being done in so interesting a branch of science and manufacture as that which was the subject of the paper.

Mr. Hale considered the Society would profit greatly by the paper.

The Chairman said the meeting evidently disagreed with Mr. Blackie. The paper was valuable, as showing what had been done so far in the science of which it treated There was much in it which could not be gone into for want of time, and the subject was so large that a dozen papers might be read upon it; certainly it was not to be expected that the whole of it could be dealt with in an hour. Pendulums were so numerous that their name was legion, though only four had come into practical use, the pendulum with the wooden rod, the gridiron, the mercurial, and the zinc and steel pendulum, which was the most modern of all. He had tested them severally, and did not like the gridiron, but the wooden one performed exceedingly well, and a clock so fitted would perform within a second or two for several weeks.

The Chairman said one such clock had belonged to the late Mr. Sheepshanks, after whose death it came to the Observatory at Greenwich, and had been there tested. There might not be a great deal to choose between the mercurial and the zinc and steel pendulums, but the latter was the most portable, and that was a great advantage. For instance, in the late expedition to observe the transit of Venus, where pendulums had to be taken to the southern parts of the world, and an accident would have been fatal, zinc and steel pendulums had been used by preference. He had tested them, and found they did not vary more than a second or two a day in temperatures between 25° and 70°, which was an exceedingly good result. However, one disadvantage was, that when once cut it was not easily readjusted, whereas the mercurial pendulum could be readily altered. Great improvements had been made during the last generation in the manufacture of turret clocks. When the specification was issued for the Westminster clock, the stipulation that it should perform within a minute a week frightened the makers at that time; but it was found, when the clock was completed, that it really performed within a second a week. He did not know what practical difficulties there might be in the construction of chronometer balances, but thought there was great difficulty in adjusting and testing them. For that purpose makers required to have some accurate timekeeper to go by, and it seemed surprising that, in these days, there should be no general means of obtaining accurate time to seconds available to the public. Such clocks had been established in some of the large provincial towns for several years, but nothing of the kind yet existed in London. A clock, showing seconds, placed in a conspicuous place in the City, would be of great use, both to chronometer makers and to the public. The time was sent at present from Greenwich Observatory to London on two wires, one going to the Post-office Telegraph Department, and the other to the South Eastern Railway Company, and it would only be a question of expenditure to make arrangements by which electric currents could be obtained for the purpose of regulating clocks. What had been found so useful in the provinces, would surely be of utility in London, but it frequently happened that there was not the same cohesion in the metropolis as in the provinces in uniting to carry out a particular object. The establishment of public clocks of that kind would be an advantage to chronometer makers in another way also, for wealthy merchants and others would probably take a pleasure in testing their watches by them, and might thus be induced to buy more expensive watches than they have at present. Accurate time could only be ascertained by the Westminster clock from its striking, the clock being placed so high that accurate time could not practically be otherwise taken from it. Independent persons had expressed the opinion that the yearly trials of chronometers at the Greenwich Observatory had very materially stimulated the manufacture of good timepieces. The anecdote about Dent's glass spring was new to him, as he had thought the firing of heavy guns close by would certainly be detrimental.

Mr. Rigg, in reply, hoped that the meeting would find that the deficiencies remarked upon were fewer in the paper itself than in the reading during the short time he had been able to occupy. The question put about the alteration of pendulums from brass to wood was one rather for practical clock makers than for himself, but at all events the wood must be well prepared and seasoned, and must be protected from moisture. Winnerl was of opinion that the best wood to employ for the purpose was that used for the sounding-boards of pianos. In the comparison of the action of the pendulum with the balance, it had apparently been forgotten that the two were not analogous, and that it was not merely a question of dealing with the expansion of the balance, but that the inward motion must correspond with the change of the balance spring, and not to the expansion of the balance. The wood and lead pendulum was originally suggested by Mr. Baily.

Mr. Fraser thought that the rod with the rod of the

leaden bob pendulum in Dent's clock was made of close-grained mahogany.

Mr. Rigg added that in the account of Saunier's pendulum, given in this month's *Revue Chronométrique*, it was stated that it had been prepared for the Paris Exhibition, but pressure of business had prevented its being sent. In conclusion, he thanked the meeting for the kindness with which they had listened to the paper.

The meeting concluded with a vote of thanks to Mr. Rigg for his interesting paper.

ADDITIONAL LECTURES.

ON THE PRESERVATION OF ANIMAL STRUCTURES FROM DECOMPOSITION.

By Benjamin W. Richardson, M.D., F.R.S.

Lecture II.—Delivered on Feb. 10th, 1879.

After recapitulating the heads of the last lecture, Dr. Richardson proceeded to report on the specimens of animal substances which had been through the test voyage.

Specimens in case No. 2, sent out to Demerara and returned to England, at temperatures varying from 45° *Fahr. to* 110° *Fahr.*

The specimens were received at the 77th day of preservation. The four specimens of the first, or *methylene* series, were all in good preservation, but the colour was not so perfect as in those similarly preserved which had been retained in England.

The specimens of the *methylal* series were not so favourable. They all had a faint taint of decomposition.

The specimens of the third, or *cyamogen* series, were in excellent condition. The colour was perfect, and the structure firm, except in the case of the fowl. The plover cooked as if it were quite fresh, and gave no taste of the preservative, The plover as cooked was put before the members for examination.

The specimens of the fourth, or *sulphurous acid* series, were not quite so perfect. The colour was darker in all than it ought to have been. The fowl was tainted, but the others were quite free of decomposition.

The specimens of the fifth series, *sulphurous acid and lime juice*, were all fresh, except the fowl. The colour was throughout indifferent.

Two of the specimens of the sixth series, *sulphurous acid and glucose*, were good. The beef and mutton were good in colour and quite fresh, but dense in structure. The plover was shrunken, and the fowl tainted.

The two specimens in the seventh, or *nitrate of methyl* series, were well preserved, but the colour of them was not good, being faintly yellowish in tint. The structure also was rather firm.

The specimens of the eighth, or *formate* series, were excellent in colour and entirely fresh.

On the whole, nine good results were the reward of this research, and these were near to all that is wanted to claim perfection. These specimens were all placed before the meeting in open jars. The lecturer next passed to a review of our present position in regard to preservation. It was, he said, now quite clear that under a temperature of 75° Fahr. we could preserve for 75 days. What next is wanted is a means of transport under that temperature of 75°. The slag felt of Mr. Baatsch promised well. In the experiment just tried with it an error had been made in placing it between layers of thin zinc. It would be necessary to repeat the trial without zinc as a lining to the wooden case.

At the conclusion of the demonstration, Dr. Richardson referred to the work of science in respect to the food of the future, and to the comparative value of animal and vegetable foods. He said—

In the research now, and at previous times, offered to the Society, my object has been to solve, purely by scientific experiment, how putrefactive change of animal tissues may be prevented. With me, this is simply a scientific problem. Commercial men may some day utilise my work, but my object is to solve the problem on scientific grounds alone, with the full assurance that very much more than the commercial element of success is concerned in it. I find, however, that, at this moment, the question is considered purely in a commercial sense, and I am asked over and over again, whether, if I could succeed to my heart's content in holding animal food for any length of time in its fresh state, I should be really doing good service to mankind. There is a school springing up which would ignore animal food altogether as food for man—which thinks that, in days to come, men and women will look at the pictures of our modern shambles with almost as much disgust as we look at that picture of cannibal shambles which Professor Huxley has given us in one of his most charming of scientific books, "Man's Place in Nature."

It may be so; but, meantime, we ought to look on the subject as it is now before us, on all sides, before we come to a conclusion upon it. It may be worth while, therefore, now, to make what may be called a *reconnaissance*.

The school that is opposed to animal flesh as food, and that would substitute vegetable in lieu of animal food, claims for its reasons, that animal food (*a.*) is dearer; (*b.*) is of less value in sustaining quality of food; (*c.*) is less healthy, than vegetable food. These points afford a good ground for observation.

As to cheapness, we must undoubtedly give the merit of cheapness to vegetable food. This is common sense itself; for when we use animal food, we, as a general rule, first use the animal that supplied the food to transmute the vegetable food into animal. For although one flesh-eating animal may live on the flesh of another flesh-eater, the process is limited in range, and at the bottom of it there must be a first supplying animal that gets its sustenance from the vegetable kingdom. This is only saying, in other words, that there is no primitive form of food, albuminous, starchy, or osseous, in the animal world itself. We have, therefore, in procuring the animal in a state for food, to catch it or rear it, to feed it and tend it; to accept the loss of it from possible disease, to go to the expense of killing it and dressing it, and, in the end, to use, after all, but a portion of its carcase for that food which we require from it. All these acts mean money, and, as a rule, money over and above, in great part, that which is spent in merely collecting the primitive vegetable substance, which might be as directly applied to the

wants of man as indirectly through the animal. The cheapness of vegetable food is plain enough.

The next question is that of quality, or of goodness, amount of nourishment of different kinds. Let us test this fact in relation to amount of water in different foods. If you look at the large table that hangs on the wall, you will see at a glance the amount of water in all the fleshy parts of animals commonly used as foods. You will see an analysis of every joint, and you will find in the primest joints as much as 70 to 75 per cent. of water. There are some vegetables which contain more water than this, viz., potatoes, turnips, cabbages, and carrots; but there are other vegetables which contain infinitely less water. Oatmeal for example, contains only 5 to 6 per cent.; good wheaten flour, barley meal, beans, and peas, 14; rice, 15; and good bread, 40 to 45 of water, and there is one animal product which contains only from 30 to 40, viz., cheese. Taking then the value of foods as estimated by their solid value, there are, it will be observed, a large class of vegetable foods which for solid value are incomparably superior to animal flesh. Peas, beans, rice, oats, barley, and wheat, are of this class. In the animal foods specially named, there are 25 parts of solid matter to the 100; in the vegetable foods specially named, there are 86 parts.

If we compute from the solid matter the value of flesh-forming and strength-producing foods in animal and vegetable produce, we find some other useful facts. Let us take a glance at the analysis of the leg of mutton given in the table of Menié which is before us, and we shall find 24 per cent. of solid material in that popular joint—the rest of it is water—10·20 of albuminoids or flesh-forming substance, and 8·76 of fat or heat-producing substance. Let us compare that with wheat as a favourite vegetable substance, and we shall find in the 86 per cent. of the solid matter of wheat 11·50 of albuminoids, or flesh-forming substance; 71 of force-producing substance, starch with a little fat. Wheat is, by this calculation, much more valuable than leg of mutton, and the vegetarian would, I dare say, with fair argument, challenge me to many further similar comparisons. Coming, in fact, directly to matter of quality or goodness it may honestly be admitted that, weight by weight, vegetable substances, when they are carefully selected, possess the most striking advantages over animal in nutritive value. The fault of the extreme vegetarians has been that they have often not discriminated in selection, but have treated all edible vegetable matter, weight by weight, with all edible animal matter.

We are brought, then, lastly, to the question of the practical value to health and life of animal and vegetable foods. The data on which to base a comparison are not very full, for a perfect system of vegetarian feeding has not been as yet based on scientific selection of vegetable food, for the trial, amongst the members of the human family. We must consequently draw our experience, to some extent, from the members of the lower creation—flesh-feeding animals and plant-feeding animals, in striving to arrive at an approximate and fair conclusion. We have two subjects before us—the physiological and the practical. Physiologically, we must, I think, admit that in the present stage of evolution the digestive system of man is as much carnivorous as herbivorous. Man certainly has some carnivorous teeth; and, although his digestive organs proper are less complicate than those of some herbivora, such as the ox, they are as complicate as those of other herbivora, such as the rabbit. Moreover, all common animals, carnivorous so-called and herbivorous so-called, are animal feeders at one time in life; all of them which are mammifers feed on milk, which is as much an animal product as flesh; it is liquid flesh. In respect to tastes for the two kinds of food, the balance of favour is fairly divided. There is no article of food in the animal or the vegetable kingdom which man learns to crave for so madly that he cannot exist without it; neither is there any article of natural food from either kingdom that creates by the taking of it an entirely new condition of body—a new constitution. In these respects natural foods—vegetable or animal—differ from chemical substances, like alcohol, which, being themselves unnatural to the body, excite an unnatural craving, an unnatural constitution, a long series of diseases, a large annual mortality, much insanity, and much crime. All persons, therefore, can study the action of these foods with more perfect composure of mind than is sometimes felt. All may admit that in mere matter of buying vegetable food is cheapest, and all, therefore, may inquire, without bias, whether such food is equally healthy. I, who am not a vegetarian, have tried to look at the question from two or three points of view.

First, I have tried to determine whether the process of feeding on animal or on vegetable diet alters the condition of the feeder in relation to health and disease. Taking, then, the length of life as an indication of good health, I am inclined to think that vegetable feeders amongst the inferior animals have the best of it in regard to longevity. Amongst men the evidence is not so clear, because in civilised countries, where statistics of life are kept, there are no sufficient facts to guide us; while in India, where there are supposed to be races of vegetable feeders, no reliable observations of comparative longevity have yet been recorded.

When we pass to diseases in the two classes of feeders, we find that animals belonging to both classes are affected with many diseases quite independently of the question of food. The carnivora are affected with rabies and distemper, and with epidemic diseases of varied kinds; while the herbivora are not only susceptible to rabies, but to small-pox, cow-pox, glanders, farcy, influenza, pleuro-pneumonia, foot and mouth disease, influenza, and other plagues. The carnivora are affected also with such constitutional disease as cancer, and so are the herbivora, though perhaps less frequently, while both are subject to cataract. The herbivora are also subject to calculous disease, and some of both types, herbivora and carnivora are certainly liable to rheumatism. Both are subject to parasitic diseases; the carnivora to tænia and trichinous disease, the herbivora to liver fluke and cœnurus cerebralis (the hydatid disease commonly known in the sheep as "staggers" or "sturdy") not to name several other diseases of parasitic origin. Thus we may fairly say, without going further, that both types of feeders are subjected to sufficiently severe diseases, and, indeed,

after making a long list of the diseases incident to both types, with my mind blindfolded, if I may so say, as to the question of feeding, I can find no sufficient evidence to lead me, at this moment, to suppose that in respect to severe maladies, one type of feeders is more exempt from injury than the other.

When we come to mankind, the rule does not seem to be widely different. Surgeon-Major Cornish, in his recent admirable report on the Indian Famine of 1876-77, says that at one period of the famine the meat-eating class kept up their muscular power better than the others, and by their apparently well-nourished condition in the labour gangs, caused superficial observers to draw wrong inferences as to the extent and severity of the disease amongst them. But then he proceeds to explain that they really held up longer because, being flesh-eaters, they found food longer than the others did, on the carcases of the bullocks that had died, and when this resource failed they too sank rapidly. On the other hand, in favour of vegetable food, the same practical observer tells us that, during the famine, scorbutic symptoms were most marked in the districts where green vegetable food was scarce. After rain had fallen, he adds, and the poor were able to pick up green succulent food the scorbutic symptoms began to disappear. In my own experience I have seen bad results under both forms of diet, but probably in all cases from errors in selection or application of the foods. I have seen bad results from too exclusive a subsistence on animal food. That is undeniable. I have seen bad results from too exclusive a subsistence on certain kinds of vegetable food. That is equally undeniable. Men and women who have lived too exclusively on animal diet have complained to me, in professional intercourse, of symptoms which were clearly traceable to that too exclusive diet. Men and women who have tried an exclusive vegetable diet have explained to me that they have failed to subsist on such diet healthily. Others, again, in both cases, who have lived exclusively on one of these forms of diet, have declared that they were better for their exclusiveness. Those who fail to live healthily on animal diet, fail, I believe, usually because they take too much in quantity, and omit to take that green succulent acid vegetable food which is an essential addition to animal diet. Those who fail to exist on vegetable food fail because they try to subsist either on vegetables which contain an excess of water and too small a proportion of flesh-forming heat-producing material, or on vegetables which contain too little water, too much solid material, with too sparing a quantity of acid vegetable juices. The practical lesson is, that man can live most healthily on a light animal diet in combination with fresh fruits and green vegetables; and he can also live on a light diet of solid flesh-forming, heat-yielding vegetable food, if he combines it with fresh fruits and green vegetables, if, in fact, he can learn to look on the solid and dry cereal and pulse materials in the same light as if they were animal substances. If this be true, the inclination towards the adoption of a vegetable diet is supported by natural fact, and the increasing repugnance which is growing up to animal flesh as food may find its vent in a resort to vegetable foods, so that they may come into general if not into universal use. At the same time, there is this difficulty in the advancement of economy by the use of vegetable food, that many persons will always be found who, in spite of repugnance or other objection to animal food, will digest vegetable food that has been prepared for them by passing through the systems of other animals better than when they themselves take it first hand from the plant. The pulses produce in most persons flatulency and dyspepsia. Oatmeal causes in many persons heat and dryness of the skin, even when taken with lime juice or fresh fruit; and other difficulties could be named which at the present beset the vegetarian in his path. Are these difficulties unsurmountable?

I answer this question as I have answered it before. They are not unsurmountable, but an inquiry is demanded on the point whether the transmutation of vegetable food which now is obtained by the digestion and passage of the food into the tissues of herbivorous animals, may not be effected by chemical processes apart from the intermediate animal altogether. When the most scientific instruments possessed by man were the flint head, the iron lance, the bow, the boomerang, the sling and stone, the fowling-piece, the rifle, and other weapons, for destruction of the inferior animals, or when he had advanced only to the process of herding and feeding animals for slaughter, this question of transmutation of vegetable food without the intervention of vegetable feeders could not be thought of. In the present day the circumstances are entirely changed. We know now, to a nicety, the relation of the various parts of food, &c., for the construction of the living body from food, and there should be no difficulty, except the labour of research, in so modifying food taken from its prime or vegetable source as to make it applicable to every necessity without the assistance of any intermediate animal at all. Changes quite as difficult have been accomplished by scientific research in the laboratory. When Boerhaave and his school began to separate the proximate active parts of vegetables from their crude masses, there was as difficult a task in hand, and that was mastered. When Thomas Thomson and his school commenced to separate out the bases of vegetable organic origin, and to determine their elementary compositions, the task was as difficult, but it was accomplished. When Liebig and his school began to attempt the synthesis, the artificial production of organic compounds from inorganic, the task was as difficult, more surprising, and more uncompromising; yet that was sufficiently accomplished to prove the success of the attempt. Let us, then, who are men of science, look at this problem. Let us, in patient research for a few years, follow up the artificial digestion and condensation of vegetable foods by synthetical imitations, and assuredly the perfect production of perfect food from the vegetable kingdom, without the aid of the intermediate lower animal, will be another triumph of science over nature. In the presence of such a development, food of the best kind would become the cheapest of all products, and would be so under the control of man, that new races of men, constructed on better food than has ever yet been prepared, would rise up to demonstrate the greatness of the triumph, by their improved physical endowments and their freedom

from diseases, which must always occur so long as other living animal bodies are demanded for the reconstruction of the human body. In a future lecture I shall hope to show some little progress towards actual success in the line of new research I have now only ventured to indicate.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at Eight o'clock:—

MARCH 19.—"Economical Gardens for Londoners." By W. MATTIEU WILLIAMS, Esq., F.R.A.S., F.C.S. Lord ALFRED S. CHURCHILL, Chairman of the Council, will preside.

MARCH 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor BARFF, M.A. F. A. ABEL, Esq., C.B., F.R.S., will preside.

APRIL 23.—"English Fresh-water Fisheries." By J. WILLIS-BUND, Esq., Chairman of the Severn Fishery Board.

APRIL 30.—Renewed Discussion on Mr. John Hollway's paper (read February 12) on "A New Process in Metallurgy." Prof. H. E. ROSCOE, F.R.S., will preside.

AFRICAN SECTION.

Tuesday Evenings, at Eight o'clock.

MARCH 18.—"Africa, a Paramount Necessity for the Future Prosperity of the Leading Industries of England." By JAMES BRADSHAW, Esq., of Manchester. Sir T. FOWELL BUXTON, Bart., will preside.

After the reading of Mr. Bradshaw's paper there will be a general discussion on the various schemes that have been proposed for the introduction of trade and civilisation into the interior of Africa.

CHEMICAL SECTION.

Thursday Evenings, at Eight o'clock.

MARCH 27.—"The Inoxidation of Iron and the Coating of Metals and other Surfaces with Platinum, by the Processes of Mons. Dodé." By L. M. STOFFEL, C.E.

APRIL 24 and MAY 22.—On these evenings Mr. W. H. PERKIN will bring before the Section a Sketch of the History of the Aniline Colours.

INDIAN SECTION.

Friday Evenings, at Eight o'clock.

MARCH 28.—"The Practicability and Advantage of a Ship Canal through the Island of Ramiseran." By SIMON MCBEAN, Esq., C.E.

MAY 2.—"On the Wild Silks of India, especially Turvah." By THOMAS WARDLE, Esq.

CANTOR LECTURES.

The Second Course is by Dr. W. H. CORFIELD, M.A., on "Dwelling-houses: their Sanitary Construction and Arrangements."

LECTURE V.—MARCH 17.

Sewerage.—Main sewers and house branches, traps, ventilation, &c.

LECTURE VI.—MARCH 24.

Water-closets, Sinks, and Baths.—Arrangements of pipes, traps, &c.

MEETINGS FOR THE ENSUING WEEK.

MON......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. W. H. Corfield, "Dwelling Houses; their Sanitary Construction and Arrangements." (Lecture V.)
Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. H. J. Castle, sen., "Contributive Value."
Medical, 11, Chandos-street, W., 8½ p.m.
Asiatic, 22, Albemarle-street, W., 3 p.m.
Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. Rev. E. Duke, "Geological Ages and the Mosaic Cosmogony." (Intermediate.)
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. R. A. Proctor, "Life in Other Worlds."
Social Science Association, 1, Adam-street, Adelphi, W.C., 8 p.m. Mr. W. H. Michael, "The Coroner's Bill."

TUES....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (African Section.) Mr. James Bradshaw, "Africa, a Paramount Necessity for the Future Prosperity of the Leading Industries of England."
Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture X.)
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. 1. Discussion on "Movable Bridges;" and, time permitting, 2. Mr. James N. Douglass, "The Electric Light applied to Lighthouse Illumination."
Statistical, Somerset-house-terrace, Strand, W.C., 7¾ p.m. Mr. H. Hayter, "The Colony of Victoria; its Progress and Present Position."
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.
Zoological, 11, Hanover-square, W., 8½ p.m. 1. Dr. G. Oartlaub, "A New Species of Barn Owl from the Island of Viti-levu." 2. Mr. Edward R. Alston, "Female Deer with Antlers." 3. Mr. Sclater, "Remarks on some Parrots living in the Society's Gardens."
Royal Colonial, St. James's-hall, Regent-street, W. The Honourable Sir Arthur H. Gordon, "Figi."
National Lifeboat Institution, Willis's-rooms, St. James's, S.W., 3 p.m. Annual Meeting.

WED.... **SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. W. Mattieu Williams, "Economical Gardens for Londoners."
Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. George Dines, "Dew, Mist, and Fog." 2. Rev. William Clement Ley, "The Inclination of the Axes of Cyclones." 3. Mr. Robert H. Scott, "Contributions to the Meteorology of the Pacific. No. III. Samoan or Navigator Islands."
Archæological Institution, 32, Sackville-street, W., 8 p.m. 1. Mr. H. Soper Cuming, "Ancient Thimbles." 2. Rev. Prebendary Scarth, "Roman Inscription Found at Bath."
Royal College of Physicians, Pall-mall East, S.W., 5 p.m. (Croonian Lectures.) Mr. W. H. Stone, "Some Applications of Physics to Medicine." (Lecture I.)

THUR....Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W., 8 p.m. 1. Mr. Frederick Smith, "New Aculeate Hymenoptera from the Sandwich Islands." 2. Mr. Thomas Sim, "The Asexual Reproduction of Ferns." 3. Mr. R. Bowdler Sharpe, "Recent Collections of Birds from South-Eastern New Guinea."
Chemical, Burlington-house, W., 8 p.m. 1. Dr. E. Frankland and Mr. A. Lawrance, "Per-Plumbic Ethide." 2. Messrs. C. F. Cross and A. Higgin, "The Decomposition of Water by Certain Metalloids." 3. Mr. W. J. Sole, "The Volumetric Determination of Chromium." 4. Mr. W. Foster, "The Production of the Higher Oxides of Iron, Chromium, Manganese, and Bismuth."
London Institution, Finsbury-circus, E.C., 7 p.m. Mr. E. Dannreuther, "Living Composers for the Pianoforte."
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Tyndall, "Sound." (Lecture VI.)
Numismatic, 4, St. Martin's-place, W.C., 7 p.m.
Royal Society Club, Willis's-rooms, St. James's, S.W. 6 p.m.

FRI.......Royal United Service Institution, Whitehall-yard, 3 p.m. Mr. J. R. Ravenhill, "The Latest Improvements in Marine Engines and Boilers."
Royal Institution, Albemarle-street, W., 8 p.m., Weekly Meeting 9 p.m., Prof. Abel, "Recent Contributions to the History of Detonating Agents."
Philological, University College, W.C., 8 p.m. Prof. Ascoli, "The Old Irish MSS. of the Ambrosian Library."
Royal College of Physicians, Pall-mall East, S.W., 5 p.m. (Croonian Lectures). Mr. W. H. Stone, "Some Applications of Physics to Medicine." (Lecture II.)

SAT......Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Capt. Abney, "Selective Reflection." 2. Dr. F. Guthrie, "The Fracture of Colloids."
Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Mr. F. Seymour Hayden, "Etching." (Lecture I.)

JOURNAL OF THE SOCIETY OF ARTS.

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FRIDAY, MARCH 21, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1879, early in May next. This medal was struck to reward "distinguished merit in promoting Arts, Manufactures, or Commerce," and has been awarded as follows:—

In 1864, to Sir Rowland Hill, K.C.B., "for his great service to Arts, Manufactures, and Commerce, in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefits of which have, however, not been confined to this country, but have extended over the civilised world."

In 1865, to his Imperial Majesty, Napoleon III., "for distinguished merit in promoting, in many ways, by his personal exertions, the international progress of Arts, Manufactures, and Commerce, the proofs of which are afforded by his judicious patronage of Art, his enlightened commercial policy, and especially by the abolition of passports in favour of British subjects."

In 1866, to Professor Faraday, D.C.L., F.R.S., for "discoveries in electricity, magnetism, and chemistry, which, in their relation to the industries of the world, have so largely promoted Arts, Manufactures, and Commerce."

In 1867, to Mr. (now Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S., "in recognition of their joint labours in establishing the first electric telegraph."

In 1868, to Mr. (now Sir) Joseph Whitworth, F.R.S., LL.D., "for the invention and manufacture of instruments of measurement and uniform standards, by which the production of machinery has been brought to a state of perfection hitherto unapproached, to the great advancement of Arts, Manufactures, and Commerce."

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For.Memb.R.S., Chevalier of the Legion of Honour, &c., "for his numerous valuable researches and writings, which have contributed most importantly to the development of food economy and agriculture, to the advancement of chemical science, and to the benefits derived from that science by Arts, Manufactures, and Commerce."

In 1870, to M. Ferdinand de Lesseps, "for services rendered to Arts, Manufactures, and Commerce, by the realisation of the Suez Canal."

In 1871, to Mr. (now Sir) Henry Cole, C.B., "for his important services in promoting Arts, Manufactures, and Commerce, especially in aiding the establishment and development of International Exhibitions, the development of Science and Art, and the South Kensington Museum."

In 1872, to Mr. Henry Bessemer, "for the eminent services rendered by him to Arts, Manufactures, and Commerce, in developing the manufacture of steel."

In 1873, to M. Michel Eugène Chevreul, For.Memb.R.S., "for his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world."

In 1874, to Dr. W. C. Siemens, D.C.L., F.R.S., "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the Arts; and for his improvement in the manufacture of iron; and generally for the services rendered by him in connection with economisation of fuel in its various applications to the Manufactures and the Arts."

In 1875, to M. Michel Chevalier, "The distinguished French statesman, who, by his writings and persistent exertions, extending over many years, has rendered essential service in promoting Arts, Manufactures, and Commerce."

In 1876, to Sir George B. Airy, K.C.B., F.R.S., the Astronomer Royal, "for eminent services rendered to Commerce by his researches in nautical astronomy, and in magnetism, and by his improvements in the application of the mariner's compass to the navigation of iron ships."

In 1877, to Jean Baptiste Dumas, For.Memb.R.S., member of the Institute of France, "the distinguished chemist, whose researches have exercised a very material influence on the advancement of the Industrial Arts."

In 1878, to Sir Wm. G. Armstrong, C.B., F.R.S., D.C.L., "because of his distinction as an engineer and as a scientific man, and because by the development of the transmission of power—hydraulically—due to his constant efforts, extending over many years, the manufactures of this country have been greatly aided, and mechanical power beneficially substituted for most laborious and injurious manual labour."

The Council invite members of the Society to forward to the Secretary, on or before the 26th of April, the names of such men of high distinction as they may think worthy of this honour.

THE LATE MR. LE NEVE FOSTER.

At the last meeting of the Committee of the "Le Neve Foster Testimonial Fund," the following circular was approved, and ordered to be circulated among the members of the Society and others:—

Society of Arts, Adelphi, W.C.
4th March, 1879.

Sir,—The Committee of the Society of Arts appointed last year to raise a Testimonial Fund for the benefit of their Secretary, Mr. P. Le Neve Foster, on the completion of his 25 years' active service in connection with the Society, have to report with deep regret the loss the Society has sustained by his sudden and unexpected death.

The Committee were about to close their labours by the presentation to Mr. Foster of the sum of £1,200 subscribed for that purpose, when the sad event occurred, and it is with much concern that they have to inform the Members of the Society that the circumstances in which Mrs. Foster has been left are such as to demand a fresh effort to increase the fund for her benefit.

The important services rendered by Mr. Foster as Secretary during a quarter of a century, and the high position to which, mainly through his instrumentality, the Society has been raised in numbers, in influence,

and in usefulness, are patent to all, and the Committee are gratified at being able to append to this communication the very kind letter in which H.R.H. the Prince of Wales, the President of the Society, has expressed his sympathy with Mr. Foster's family and the Society at his loss.

Several of those who have taken part in the Testimonial have expressed their intention to increase their previous subscriptions, and it is thought that many others may be willing to do the same. It is also hoped that there may be those who, not having previously subscribed, will be disposed to do so under the present circumstances.

I am, Sir,
Your obedient Servant,
Alfred S. Churchill, Treasurer.
(*Chairman of the Council*).

[enclosure.]

Hotel de France, Bordeaux,
26th February, 1879.

Dear Lord Alfred Churchill,—The Prince of Wales has learnt with extreme regret and pain the intelligence of the death of Mr. Le Neve Foster, and he desires me to ask you to be so good as to take an opportunity of expressing to the Members of the Council of the Society of Arts the sense which he entertains of the services rendered to the Society by their late Secretary, and of the able, zealous, and energetic manner in which he conducted their business for so many years. His loss is a very great one, and it will be a most difficult matter to find a suitable successor.

His Royal Highness is not aware if Mrs. Foster is left well off or not, but should there be any intention to present her with a testimonial in some shape or another, in memory of her husband, he directs me to say it will give him much pleasure to join in it.

Believe me,
Yours very truly,
(Signed) Francis Knollys.

Subscriptions may be paid to the credit of the Fund, at Messrs. Robarts, Lubbock & Co.; or at Messrs. Cox, Biddulph & Co.; or they may be sent to the Secretary of the Society of Arts. Cheques should be made payable to the "Foster Testimonial or Order," and crossed Robarts, Lubbock & Co.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference will be held in the Rooms of the Society of Arts, on Thursday and Friday, the 15th and 16th May, 1879, on National Water Supply, Sewage, and Health, the Right Hon. James Stansfeld, M.P., late President of the Local Government Board, in the chair, assisted by the members of the Executive Committee:—Lord Alfred Churchill (Chairman of Council); Sir Henry Cole, K.C.B.; Colonel Sir E. Du Cane, K.C.B.; Captain Douglas Galton, C.B., F.R.S.; Mr. F. A. Abel, C.B., F.R.S.; Mr. T. W. Keates; Dr. Voelcker, F.R.S.; Mr. W. Hawes, F.G.S.; Major-Gen. F. Cotton, R.E., C.S.I. Papers relating to the above subjects will be read and discussed.

Programme of Proceedings.

The Conference will meet each day at 11 a.m., and sit till 1.30, then adjourn till 2, and sit again till 5 p.m., and, if necessary, meet again at 8 p.m.

Thursday, 11 a.m.—Opening of the Proceedings by the Chairman.
Papers and Discussion.

Friday, 11 p.m.—Proceedings will be resumed.
Papers and Discussions continued.

There will be an Exhibition of Mechanical and Chemical Apparatus in connexion with Water Supply, Treatment of Sewage, and Health. All articles for exhibition must be delivered, carriage free, not later than Saturday, the 10th May, 1879. Manufacturers and others desiring to exhibit should communicate forthwith with the Secretary of the Society of Arts.

Papers on any of above heads are requested.

The object of the Conference is to discuss existing information in connexion with the results of any systems already adopted in various localities, referring to the subjects of National Water Supply, Sewage, and Health; to elicit further information thereon; and gather and publish, for the benefit of the public generally, the experience gained. The introduction and discussion of untried schemes will, therefore, not be permitted. The papers accepted for the Conference will be printed and circulated at the Meetings.

Prize Medals.

1. The Council of the Society of Arts offers one Gold and three Silver Medals for the best suggestions, founded upon evidence already published, for dividing England and Wales into districts, for the supply of pure water to the towns and villages in each district.

2. The districts should be laid out on a skeleton map scale, which can be obtained from Mr. Stanford, 55, Charing-cross, price 6d. each.

3. The average rainfall in the district should be stated; also the population of the district, and its geology.

4. The suggestions should be written on foolscap, half-margin, and sent, accompanied by maps, under cypher, to the Secretary of the Society of Arts, on or before the 26th day of April, 1879.

5. The maps will be exhibited, and the suggestions will be discussed at the Conference on National Water Supply.

6. The Council will invite the assistance of eminent authorities to recommend the competitors worthy to receive the prizes; but the prizes will be withheld if the suggestions made do not appear to the judges to be of sufficient merit.

CHEMICAL SECTION.

Thursday, March 13th. T. WILLS, F.C.S., in the chair.

The paper read was—

THE INJURIOUS EFFECTS OF THE AIR OF LARGE TOWNS ON ANIMAL AND VEGETABLE LIFE, AND METHODS PROPOSED FOR SECURING SALUBRIOUS AIR.

By William Thomson, F.R.S.E., F.C.S.

In considering these questions, it is important that we should have clear ideas—first, as to what is pure air; secondly, for comparison, what alteration in the constituent parts of air would make it incapable of supporting life (say, for instance, air in which a candle could not burn); and, thirdly, between this wide gulf, what may be termed impure or unhealthy air.

Air is composed principally of a mixture of two gases, oxygen and nitrogen, in the proportion of about 21 volumes of the former, and 79 volumes of the latter. Oxygen is the constituent which supports life and combustion; nitrogen is an inert gas, which was doubtless intended by the Creator to dilute the active or life and combustion sustaining gas, oxygen.

The following may be regarded as an analysis of the purest air which can be obtained:—

	Per cent. by volume.
Oxygen	20·999
Nitrogen	77·568
Carbonic acid gas	·033
Water vapour	1·400
	100·000

Dr. Angus Smith found that if he abstracted about $2\frac{1}{2}$ per cent. of oxygen from pure air, it would not support the combustion of a candle, and it would be impossible for anyone to live long in such an atmosphere; so that the air, so far as life is concerned, may be compared to a reservoir with pipes placed near the top—the water under the level of the pipes being useless, except as affording a support for the top stratum, which can be utilised by being drawn off; so we have 18·5 per cent. of the oxygen of the air of no greater value, as a life supporter, than the water which lies under the level of the pipes of our assumed reservoir, and we may take it, therefore, that only one-eighth part of the volume of the oxygen of the air is of practical value.

We must, then, look upon air which has even a very minute fraction less of oxygen than that given in the above analysis, as more or less objectionable or bad, because the part of the total amount of oxygen contained in the atmosphere available for supporting life is so small.

The following analysis made by Dr. Angus Smith shows the actual proportions of oxygen contained in air from different places, the last four of which cannot be regarded as otherwise than unhealthy:—

	Per cent. by volume of oxygen.
Tops of hills (Scotland)	20·980
In the outer circle of Manchester (not raining)	20·947
Low parts of Perth	20·935
In a sitting-room which felt close but not excessively so	20·890
Pit of a theatre, 11.30 p.m.	20·740
About backs of houses and closets	20·700

It will be observed, then, that judging from the deficiency of oxygen alone in the air from the pit of a theatre, for instance, a draught of over 10 per cent. has been made upon the total available oxygen. Judging, however, from this point of view, we are assuming that the place of the oxygen abstracted is filled by an innocuous gas, such as nitrogen, which is not the case. When the oxygen is consumed by man, it combines with the carbon from his lungs, forming carbonic acid gas, which may be regarded as a positive poison, and if we take the amount of this noxious gas found in a theatre, we see by Dr. Smith's analysis, that it amounts to 0·320 per cent., being 10 times greater than that found in pure air. In Manchester streets, in ordinary weather, the air was found to contain ·0403 per cent. of carbonic acid gas, and although this is a very small fraction, it is yet about 20 per cent. greater than that found in pure air.

When we consider that a healthy man will pass through his lungs about 2,000 gallons of air per day of 24 hours, we see that he will, during that time, inhale $5\frac{1}{4}$ pints of carbonic acid gas in the country, and $6\frac{1}{2}$ pints in the streets of Manchester, and about 51 pints in an atmosphere such as that found in the pit of a theatre.

These, however, together with organic emanations, are the impurities which are found in air polluted by the breathing of animals, but these are not the only impurities found in the air of large towns; others more irritating and poisonous proceed from the burning of coal, to which I will refer later on; but to confine ourselves to the physiological effects of air charged with large quantities of carbonic acid, such as that found in a theatre, I will refer to certain statistics. It is well known that children who are kept after birth in badly ventilated rooms die in large numbers from what were termed "nine-day fits." In 1783, Dr. Joseph Clarke, master of the Rotunda Hospital in Dublin, recorded that during 25 years in that hospital, when the ventilation was bad, no fewer than 3,000 out of 18,000 children born there died within the first fortnight of their birth. The number of these cases at once rapidly diminished as soon as the better ventilation of the wards was attended to, so that, in the following 28 years, out of 15,072 children born, only 550 died, being 1 in 104, instead of 1 in 6, as was the case previous to the better ventilation; and since, Dr. McClintock, one of the successors of Dr. Clark, reported, in 1861, that further improvements having been made in ventilation, the disease was then almost unknown.

Again, in the Mediterranean squadron, a fearful lung disease made its appearance among the men in 1861, which was found to be due to the want of proper ventilation in the lower decks of the ships where the men slept. The lung is a most delicate organ, in which the blood meets with the air which we breathe. The air passes into the lungs, through air tubes, which divide and sub-divide, like the stem and branches of a tree, each branch-

let ending in a small air cell or leaf, which is formed of a delicate membrane, not more than the thickness of a soap bubble; and the lungs of a full-grown man contain six hundred millions of these leaflets, or air-bags. The membrane of these delicate air-bags is covered with fine, hair-like blood vessels, through which the blood flows, and thus spreading over an enormous surface it becomes aërated. The blood from one side of the heart, charged with the impurities, &c., which it has received from the body, passes across the lungs through the tiny blood vessels on the delicate membrane, and there meets with the air, the oxygen contained in which burns or oxidises the impurities in the blood, carrying them away as carbonic acid gas, which we exhale, along with the nitrogen and excess of oxygen. This delicate organ is protected from injury by a variety of means. If, for instance, a particle of solid matter or liquid, for instance, touches the air passages, as is sometimes the case in eating or drinking when the liquid or food is said to "pass into the wrong throat," a reflex action is produced, involuntary coughing takes place, and the intruding matter is expelled. If, however, the particles of matter be not sufficiently large to produce violent coughing, it produces a rapid secretion of mucus from the mucus membrane of the air passages, in the same way as a particle of dust coming in contact with the eye produces a flow of tears, which eventually washes away the irritating particle. The mucus, or living membrane, or skin of the air passages, is also provided with another most ingenious appliance; it is covered with myriads of minute hairs or cilia, which are in constant motion, like a field of corn in the breeze, so that when the mucus secretion, which is a glairy fluid, has taken hold of the offending particle, the movement of the small hairs passes it slowly along, till it comes near to the top of the trachea, or windpipe, when the mixture of foreign matter and mucus may be finally dislodged by coughing.

The results of this process can be observed when we breathe some time in the open air during a fog in a large town. The air then contains a copious amount of soot in suspension, which finds its way into the air passages, and which is ultimately expelled mixed with phlegm, the whole being sometimes of a dark or even black colour.

If, however, the air passages are constantly being irritated by small particles of foreign matter, the mucus membrane gradually loses the power of performing its normal functions, and becomes diseased, and this diseased condition soon extends to the lung itself. Remarkable examples are to be found of diseases originating directly from this cause in the men employed at certain manufactories, such as knife and fork grinders, where the fine particles of steel float in the air, and are inhaled by the men. The lives of the men engaged in such occupations are extraordinarily short, a knife or fork grinder being considered an old man at the age of 30, and if he has worked at his trade from boyhood without using fan appliances to take away the steel dust, as most of them do, having a strong prejudice against any such apparatus, they often commence at the age of 25 or 26 to die of a long and painful illness, resulting from lung disease.

This may serve as an example of how the lives of men may be much shortened, by the irritation resulting from inhaling minute particles of a hard and angular dust, but the minute particles of carbon which float in the air of our large towns, and which may be found adhering to the sides of the air passages of the nostrils, for instance, after one has spent some few hours in a town, assuredly have an injurious effect upon the health and lives of the inhabitants. The same kind of irritation may, however, be produced by the inhaling of noxious gases, which are also found in town air.

Many other cases of consumption being produced in strong, healthy men, by breathing impure air, may be given; but, as one more instance of the pernicious effects of bad air, we may refer to the average life-time of the people living at different places, which will speak for itself.

In London, the average	life-time is	29	years.
,, Manchester	,,	21	,,
,, Surrey	,,	34	,,
,, France	,,	34	,,
,, England	,,	29	,,

Supposing a man to take pure air into his lungs, containing, as it does, about 21 per cent. of oxygen and $\frac{3}{100}$ths of a per cent. of carbonic acid gas when he exhales it, the carbonic acid gas would be found to have increased to 5 per cent., and the oxygen to have diminished to about 13 per cent. If he were compelled to breathe again the same air, death would ensue in a few minutes; this air must, therefore, be largely diluted with pure air, and different hygienic authorities hold that each volume of air exhaled should be mixed or diluted at once with from 130 to 200 volumes of pure air, and that whilst a healthy man cannot pass through his lungs more than about 72 gallons of air per hour, he should be supplied with, at least, 10,000 gallons, that the impurities exhaled may not prove poisonous or deleterious to him.

The above facts show us the vast necessity of being supplied with pure air, and yet, strange to say, this is one of the points which by the generality of men least attention is paid. Millions of money are being spent to obtain for our towns liberal supply of pure water, which, is no doubt, most important for our welfare, but of much less importance than the supply of pure air. What a lamentable sight is presented to us, when we go to the top of a hill near to one of our large towns and look down upon it. We observe that it is enveloped in one vast cloud of smoke, and yet in such atmospheres thousands are living, suffering, and prematurely dying; and still more marked to the eye is the injurious effects which such atmospheres have upon plant life. Few plants or trees can grow in or near our large towns, and those which do stand better these injurious influences become weaker and weaker every year, until they ultimately succumb.

We ask what is the cause of this, and the answer is undeniable. It is owing to the gases produced from the burning of coal. When coal is consumed, a large number of different products of combustion are formed, which escape up the chimney and enter the outside air. Coal is burned in large towns for two purposes, the one for the processes of manufacturing, the other for heating our rooms and for culinary purposes. Up to the present time, wealth has almost entirely ignored the nuisance produced

from the house smoke, but has acted vigorously against that produced from manufactures; and although this is a step in the right direction, it is unfortunate that it has only attacked by far the lesser of the two nuisances.

The smoke or gases produced from coal used in manufacturing are of a different composition from those produced by coal burnt in the ordinary room or kitchen grates In the former, the coal and its products are more completely burned than in the latter; that this is so may be observed by looking at a room-fire in comparison with the fire under a large boiler. The general mode of keeping up the fire in an ordinary room grate is to put some pieces of coal on to it when necessary, either as large pieces when the fire is intended to last for some considerable time, or as small pieces, or as a mixture of both, when a good fire is required; in any case we may observe, when this is done, that a distillation takes place, and a yellow vapour begins to flow slowly up the chimney, and later on these products become ignited; on the other hand, the gases evolved from the coal by distillation in the front are completely consumed in passing over the red-hot fuel in the back part of the furnace. The smoke, therefore, from domestic fires is of a more complicated nature, and more injurious to the health of men and animals than the thoroughly burned products which escape from furnace fires, and not only so, but the smoke from domestic fires is distributed all over our towns, and allowed to escape into the air generally not more than a few yards from the level of the streets, and it is wafted down by the wind or air currents, contaminating the air which we have to breathe, and making it look as if a faint haze existed everywhere in our town atmospheres; indeed, in my opinion, the sanitary conditions would not be materially improved if all the manufacturing industries at once ceased to exist. This is borne out by a paper read before the Manchester Philosophical Society by Mr. Peter Spence in 1869, in which he describes the results of a series of experiments made at his own house with blue litmus paper. These papers were changed morning and evening for some time, until he became an expert judge of changes in colour produced by the air blowing from different directions. He found, as a rule, that on Saturdays, when the manufactories were not working, more acidity was observed in the air than on any other day or night in the week.

The principal impurities found in the air of large towns are soot, hydrocarbons, sulphide of ammonium, carbonic acid, sulphurous acid, carbonic oxide, and probably very minute quantities of arsenic expelled from the pyrites existing in the coal. All these are due to coal smoke, others exist such as emanations from putrid or decomposing organic matter, but by far the greatest quantity of atmospheric impurities in large towns can be traced to the emanations from burning coal. The sulphur compounds contained in the different atmospheres is regarded by Dr. Angus Smith as a measure of the pollution of the air from coal smoke and other causes, such as putrefaction and decomposition, but principally from the former, and these compounds, such as sulphurous and sulphuric acids, &c., he has estimated; and, calculating the sulphur compounds into sulphuric acid, he has arranged the following interesting table of results. Taking the sulphates in the air found in Valentia, in Ireland, as 100, we have the following amounts found in various places throughout the United Kingdom:—

Scotland.—Sea-coast country places, west	132·2
England.—Inland country places	202·2
Scotland.—Towns (Glasgow not included)	604·4
London, 1869	750·5
English towns............................	1255·3
Manchester, 1869	1526·
,, 1870	1757·8
Glasgow	2591·

Again, Dr. Smith compares the amount of acidity, or free acid in the air of different places. The free acid, as a rule, comes directly from the burning of coal, and may be regarded specially as the plant-destroying ingredient of town air. He gives the amount of ammonia which is eliminated principally from the burning of coal, and the following gives some of these results. In the case of acidity, the air of Valentia contains none, and cannot, therefore, be taken as a standard of comparison; but, for ammonia, the amount found therein is taken as unity. Here follows the table:—

	Acidity.	Ammonia.
IRELAND.—Valentia	None.	1
SCOTLAND. — Sea-coast country places, west	1	2·69
ENGLAND.—Inland country places	None.	5·94
London, 1869	27·97	19·17
Manchester, average of 1869 and 1870	73·44	35·94
Ditto, 1870	86·76	36·54
Glasgow	109·16	50·55

The question has often been raised as to whether black smoke did more damage to animals and plants than the products of the complete combustion of coal, and some held the view that black smoke was innocuous, whilst others held that it was highly deleterious.

It has been shown that if a plant be completely covered with pure carbon, the plant will grow luxuriantly, but it has also been shown that soot is not pure carbon, but is carbon saturated with sulphurous and sulphuric acids, tarry matters, ammonia salts, &c., and it has been equally clearly shown that soot or black smoke is highly destructive to plant life. The soot, or black smoke, no doubt acts injuriously on plants in two ways, the first mechanically, by the tarry ingredients interfering with the free action of the stomata, or breathing orifices of the leaves; the second chemically, by the acids, salts, and other substances which would be washed from the smoke deposited on the leaves by the dew or rain which comes in contact with it, these substances would be absorbed into the substance of the leaf, and, coming in contact with the juices of the plant, would decompose it, and so render it incapable of imparting nourishment. It is remarkable to observe that the leaves of plants and shrubs in large towns are generally so thickly covered with smoke, that, if they be rubbed between the fingers, the latter will be much soiled, or completely blackened. The effect of the air of large towns is to prevent the early budding of the leaves of the trees and plants, and to make the leaves fall early in the autumn, or before it sets in. It is clear, then, that i would

be a great advantage, to both animal and plant life, if black smoke were not emitted from chimneys, because it falls rapidly on to the plants, bringing with it, and consequently acting as a vehicle for carrying, the really noxious ingredients of the smoke. It also falls on and blackens the magnificent public buildings which most English towns possess; and, not only so, but injures the stone and carving exposed to it, by reason of the dirt being washed from it into the stone, many kinds of which ultimately undergo a crumbling process from that cause. It is evident, then, that it is important that, if possible, coal should be burned thoroughly, and no black smoke produced, because, as I have mentioned, it injures, not only plant and animal life and buildings, but soils everything which the good housewife considers worthy of being kept free from stain. If, then, it be found that cleanliness can only be obtained or retained at an immense cost of labour, many will lose heart, and become contented to remain dirty; and so the emission of black smoke from chimneys should and does prove a great social evil. If, however, the smoke were completely consumed whenever coal is used, the evil would not be stamped out, because the rain which falls in large towns dissolves from the atmosphere the impurities which it brings down with it, and which prove highly deleterious or poisonous to the plant. It is calculated that about 1½ millions of tons of ammonia, or salts of ammonia, are dissolved per annum from the atmosphere by the rain which falls on the globe, and this furnishes the plants with a most valuable food—the ammonia being formed in nature by the electric discharge, or lightning, or by the decomposition of animals and plants. What a vast difference is presented by the rain water which falls in and near towns. If a vessel be exposed in a town the rain water falls into it, but so does the black smoke, and after a few days if the water and soot which has fallen be mixed together, the liquid will present an inky appearance, and will change the colour of blue litmus to red, whilst a vessel left for the same length of time in a country place will be free from sooty or noxious ingredients.

Lastly, I may mention that it has been calculated that about two millions of pounds worth of property are destroyed in London and its vicinity alone per annum by the emanations from burning coal. I do not vouch for the accuracy or otherwise of the last calculation, but, doubtless, we have sufficient proof that an immense amount of property is annually destroyed by allowing coal smoke to enter our atmosphere, as it does at the present time in England; and this is one of the points which weighs heavily in the scale on one side to show that, even if some scheme were devised and worked, even at great cost, it is probable that, looked at from a commercial point of view, from depreciation by damage to property alone, the scheme might prove a success; but this is one of the least important items in the problem. One which stands much higher is the increased degree of health which even the strongest of town inhabitants would experience, even by a small mitigation of the amount of impurities thrown into the air. I think that any one who works in the vitiated atmospheres of towns must feel, if he has tried it, that he can do more work, and can do it more easily and comfortably, in the atmosphere of a country place than in that of a town, and further, that he requires less food when working in a pure atmosphere then when employed in a vitiated one, the wear and tear on the system being much greater in the latter.

If, then, it were possible to secure a fine atmosphere in towns, what a vast benefit would be conferred upon the inhabitants. It would tap thousands of springs of energy which at present are kept dormant, and that energy, if directed towards the development of the country would bring back to it much of the prosperity of which it at present so much needs; but, above all, it would give an increased supply of good health and spirit, and would prevent many of our unfortunate citizens from wasting their money and destroying themselves mentally, morally, and physically, by excessive indulgence in stimulants.

So much, then, for the benefits which would be gained by improved sanitary conditions of our atmospheres; and I come now to the question whether it be practicable to prevent much of the contaminations which at present find their way into our atmospheres, and I think there can be no doubt that it is. Schemes have been discussed of draining away the noxious gases from our chimneys, and passing them along the sewers, and ultimately allowing them to escape into the atmosphere from the tops of tall chimneys, but nothing was brought forward of a definite nature till Mr. Peter Spence, F.C.S., of Manchester, the well-known manufacturing chemist, made the necessary calculations, and embodied his scheme in a paper read before the Manchester Philosophical Society, 22 years ago. To give his ideas in as few words as possible, he says that it is practicable to build a chimney 600 feet high, 140 feet external diameter at the bottom, and 100 feet internal diameter at the top, at a cost of about £40,000, and calculating the amount of air required for the complete combustion of the whole of the coal burned in Manchester, assuming that that air would enter the tall chimney at a temperature of 100° Fah. (about the temperature of the human body), the column of air would ascend at the rate of about 40 feet per second, and would be capable of carrying away about ten times as much air as that required for the combustion of all the coal employed in Manchester.

We may assume, however, that if such a chimney were built, and subsequently found incapable of doing the necessary drainage work, it is possible that a large fan could be erected in connection with the chimney, and the draught so aided by mechanical power.

The scheme has many interesting points connected with it. First, it combines the liquid and gaseous sewage, and makes the one in many respects neutralise the other. The sulphurous acid, hydrocarbon, &c., from the coal smoke would prevent the decomposition of the liquid sewage, whilst the liquid sewage would condense much of these noxious substances from the smoke which now contaminate our atmosphere. Again there would be a constant draught through the sewers, and, consequently, it would be impossible for any foul air to escape from them; on the contrary, if there should happen to be any leak in the sewers, the pure air would flow into them, instead of, as is the case at the

present time, the foul air of the sewers finding its way out from every crack into our houses; because it seems almost practically impossible to keep sewers so tight that objectionable smells will not proceed from them—when one place is made tight the bad odours make themselves evident from another. Mr. Spence relates an interesting method by which he prevented the sewer gases from entering his house. He found that one of the bedrooms in a house which he had occupied for a short time could not be used, owing to the bad smells which evidently found their way through some cracks in the wall of the room, and he hit upon the plan of joining a 4-inch iron pipe with the sewer at one end, and placing the other end a few feet up the kitchen chimney. The draught from the chimney so far ventilated the flue that the smell from the bedroom, almost immediately after this arrangement was completed, ceased to exist. This scheme might materially help the solving of the liquid sewage problem, inasmuch as less water would be required to be passed along the sewers, and the slightly diluted sewage would, in its passage along, meet and dissolve from the coal smoke the ammoniacal salts which it contains, and the liquid might afterwards be treated directly for the recovery of these valuable products, which might be converted into the products richer in plant nourishment than the richest guanos.

Mr. Spence calculated that, by the burning of two millions of tons of coal in Manchester and Salford, about 20,000 tons of sulphate of ammonia could be produced, all of which, by his scheme, would be deposited in the tunnels and added to the sewage; and, taking its average value at £15 per ton, would be worth £300,000, a heavy item to be thrown away uselessly and harmfully into the atmosphere, and, taking this in combination with the manurial value of the sewage, he considers that about £800,000 per annum might be realised by its sale. This, then, is another point which adds to the prospect of the financial success of such a scheme.

Other schemes have been suggested for the prevention of the pollution of our atmosphere, such as the preparation of purified coal gas from the coal, and using that as fuel. We are, however, a conservative people, and any material improvements which are made must be done slowly and cautiously. I understand that Mr. Spence's system has been adopted at the Assize Courts in Manchester, where all the fires are ventilated into the same chimney, and that it will be adopted in the New Law Courts of London; whilst I believe that the full scheme advocated by Mr. Spence and others will ultimately be adopted in all large towns. Mr. Spence, who has spent much time during his life in the study of those matters, and who has a thorough knowledge of what work can be done by large chimneys, &c., informed me a few days ago, that he saw no reason, since he first brought forward this scheme, 22 years ago, of altering his opinion as to its practicability. The point, however, which I wish to be most clearly brought forward in this paper, is that, considering the vast and growing importance of the subject, some means should at once be taken to mitigate the nuisance, and reduce the impurities which we are now compelled to breathe in our large towns, and this may be done with certainty, simplicity, and little expense, by joining all the chimneys in each block or line of buildings together, for instance, and connecting them into one chimney, which should stand considerably above the tops of the houses. Much of the impurities would be condensed and deposited in the flues before the smoke reached the chimney, and it would allow of greater diffusion of the noxious gases which escaped from its increased height, so that we should require to inhale less of them, and further it would increase the draught in every chimney so joined. The draught could then be easily regulated by dampers; and, lastly, it would be preparing the way to centralise the points at which the smoke should be allowed to escape, until lastly a chimney of immense height would take the smoke and fumes sufficiently high to prevent their ever reaching our level.

Weighed against the comparatively small expense which the carrying out of some such plan would entail, the immense benefit which would be derived from it, it certainly seems astonishing that something has not before been attempted in this direction. Each fraction of a per-centage of impurity which we are compelled to breathe adds considerably more to the drag which is thus put on the wheels of human energy, and it kills the plants and trees which were provided by nature to purify the air from the necessary contamination produced from the breathing of animals, and to refresh and delight the eye and the mind by their beauty. The smoke also prevents the free entrance to our towns of the rays of the health-giving sun.

The benefits which might be derived from having a pure atmosphere in our large towns can scarcely be estimated, and I trust that this Society will spare some of its talent and energy in the future in trying to improve the sanitary condition of the air of our large towns.

DISCUSSION.

The Chairman said there could be no question that the continued and increasing vitiation of the atmosphere of large towns was a matter of great importance. He understood this paper was to be considered merely as suggestive on this subject, with a view to draw attention to it, so that some method might be found, if possible, of mitigating this great evil. It did not seem to him personally that some of Mr. Thomson's suggestions were quite practicable, and any scheme for the purpose seemed more one for sanitary engineers than for chemists. Looked at from a chemist's point of view, it would appear to be hardly possible to deal with these products of combustion after they had been thrown into the atmosphere. The point at which they could be treated satisfactorily would be at the moment of production, and there was no doubt that, in the consumption of coal, much might be done to mitigate the nuisance which arose from the large amount of carbonaceous matter, sulphurous acid, and so forth, which was thrown into the air during its burning. Any questions which might be raised would probably resolve themselves into dealing with two sides of the question. First, the proper methods of preventing the unnecessary and abnormal elements of vitiation which passed into the atmosphere from manufactories and domestic fires, the extent of which might, no doubt, be reduced; and, secondly, the best methods of ventilating public buildings and houses, in order to free them from those products of combustion and respiration, which were, to a large extent, unavoidable. Every

full-grown man gave out into the atmosphere about seven-tenths of a cubic foot of carbonic acid per hour, as the necessary result of his respiration; he breathed the air, and converted the oxygen into carbonic acid by its union with the carbon in his blood, and this could not be prevented; in fact, it was compensated for by the fact that plants derived their nourishment from the carbonic acid thus produced. We could not prevent this carbonic acid going into the air, but it should be prevented from accumulating to an undue extent in rooms of public buildings by the introduction of a large supply of fresh air, so that the products of respiration should be diluted to such an extent that they would be innocuous.

No one else rising to address the meeting,

The Chairman said if there were no other remarks, his only duty was to ask the meeting to thank Mr. Thomson for coming from Manchester and reading this paper. He came from a part of the country where this evil was probably more felt than in London, and they were very much obliged to him for the trouble he had taken.

The vote of thanks having been passed,

Mr. Thomson, in reply, said he would simply make one remark in answer to the Chairman. It was practically impossible to treat the gases at the moment of combustion, because the sulphur which was contained in the coal and various other products could not be got rid of in that way. No matter how thoroughly they were treated, those products would escape into the air, and it was these which killed plants, and produced consumption in a large number of people living in our large towns. Therefore, it was proposed that these products should be carried to a sufficient height above our heads so that it could not come down to poison the people below. The principal object of bringing forward this paper was to ask that some interest might be taken in the matter, to arrange the chimneys on the tops of houses so that they would not pour the smoke immediately into the streets, but that it might be carried along into tall chimneys and discharged some 200 or 300 feet, or, at all events, some considerable distance above our heads. If that were done, there could be no doubt whatever that it would considerably raise the average life-time of people living in large towns, where there was so much contamination in the atmosphere.

AFRICAN SECTION.

Tuesday, March 18, 1879; Sir Thomas Fowell Buxton in the chair.

The Chairman, in introducing Mr. Bradshaw, said that the attention of the people of England had been drawn to the affairs of Africa for many years past on various grounds, all based on the idea that England and the civilised world owed a debt to Africa, and so far as it was behind the world and had been depressed in the scale of nations by the action of civilised countries in the matter of the slave trade and in other ways, we had felt bound to do something to raise Africa, and to remove as far as possible the sorrows and afflictions which had come upon her. But now another reason was cropping up in the minds of men, and a reason for raising Africa was to be found in our own condition. We need not regard this matter in any way as hopeless. A century ago India took very little of the goods of Europe, but within the century a large trade had grown up, and to a large extent the mills of Lancashire had been employed in supplying the needs of India and China. If this had been the experience of India, there was no reason why it should not be repeated in the case of Africa. This, he believed, was the view Mr. Bradshaw was going to bring forward, and he hoped an interesting discussion would follow.

The paper read was—

AFRICA; A PARAMOUNT NECESSITY FOR THE FUTURE PROSPERITY OF THE LEADING INDUSTRIES OF ENGLAND.

By James Bradshaw.

All trades being at a dead level of depression, the cotton trade of Lancashire is selected for consideration as being the leading industry of the kingdom, but all other industries are in a greater or lesser degree, prosperously or adversely influenced by the condition of the cotton trade. Lancashire has achieved its opulence by virtue of a past monopoly, during which the world came to Lancashire for its chief supply of cotton goods. The world is now straining every nerve to do without Lancashire. Most countries now possess cotton manufacturing mills. France, Germany, Russia, Holland, Belgium, Switzerland, Austria, Denmark, Sweden, Spain, Italy, America, Brazils, India have them; within the past few weeks the Chinese mandarins have ordered the spinning and weaving machinery for a cotton mill at Shanghai, and the Japanese are about to do the same. There are many who still cling to the hope that somehow or other India and China, with their teeming millions of population, will continue their increasing offtake of cotton goods in the future as they have done in the past, and that Lancashire spindles, pessimist views notwithstanding, will thus be kept going. Such require to be reminded that, only about a century ago, the cotton fabrics consumed by European nations were the product of the hand-looms of India, the birthplace of cotton manufacture; nor has this manufacture ever left India, inasmuch as one-half of the cotton fabrics consumed there are still the product of the antiquated native hand-loom. The marvel is that Lancashire has so long been allowed to enjoy her constantly-growing Indian trade; but, now that her machinery is being erected in India, she must gradually loosen, and finally relinquish, her hold upon the cotton trade of India, and largely that of China. To those who doubt such a possibility, I would put the question—Keeping in view the skill evinced in the manufacture of the most delicate cotton fabrics by the crude native hand-looms of India, what is the drift and meaning of the fact that, whereas some 20 years ago there was no such thing as a factory hand in Bombay, there are now upwards of 30,000 trained native operatives in the steam power spinning and weaving mills of India, but chiefly in the Bombay presidency? If we consider China, we again encounter an ancient manufacturing community, possessing abundance of useful cotton, and, like India, largely producing their own cotton fabrics. The importance of India and China to Lancashire may be comprehended, when it is stated that one-third of the spindles and looms of Lancashire are kept at work for the India and China markets. In other words, one-third of the labouring population, one-third of the mill, warehouse, dwelling house, and shop property of Lancashire has been necessitated or created by our India and China trade. If it be admitted that the monopoly which made Lancashire has passed away, the gravity of this fact should command national attention. In the build-

ings and machinery alone of Lancashire—cotton mills, machine, engineering, bleaching, dyeing, printing, and chemical works, there cannot be less than £100,000,000 (one hundred millions sterling) sunk. This property is nonconvertible, and ultimately valueless, unless the industry which created it can be sustained in a paying condition (at the present moment the best and newest mills in Lancashire can be bought for less than 10s. in the pound), but to the naked cost of manufactories must be added the capital sunk in the land, houses, warehouses, mines, railways, ships, docks, &c., of Lancashire, mostly deriving their value or existence from this wonderful cotton industry. The sum total of all these values is, perhaps, not far short of the National Debt; anyhow, it is so tremendous as affecting the nation, that the ability to continue these properties at an intrinsic worth of 20s. in the pound, or allowing them to permanently sink below this figure, indicates commercially a grand national future or a gradual national decay. Commercial England is at present moribund with the lethargy which comes of despair. Why this despair? Because nothing pays, and it is tacitly felt that present and prospective loss, ending in penury, are inevitable, and few can see from where or how the redeeming better future is to come. This is the state of feeling on the Manchester Exchange, which may be taken as reflecting the feeling of the whole country commercially. Fathers of the middle class see no outlet or suitable occupation for the energies of their sons, and their daughters are not taken in marriage, because thousands of our young men, fit to go anywhere and to be trusted with anything, find it difficult to keep themselves, and, therefore, impossible to think of keeping wives and families. The pinch of decreasing incomes is intensifying, and absolute want of the necessaries of life is now being experienced in the homes of working men, while capital and labour, in the struggle for existence, present the sad spectacle of destroying each other. Various suggestions are propounded as a panacea for the difficulties confronting us, such as change of Government, emigration, giving up free trade and returning to protection, lowering wages, curtailing production, society to return to a simpler and less expensive style of living, &c., but these only deal with the fringe of the difficulty, and are expedients which at best could only bring temporary relief. What, then, is the one thing wanting for the languishing industries of Great Britain — undoubtedly a new great continent to trade with, possessing population and natural wealth which centuries of commercial development cannot exhaust. These requisites we have in Africa, of which grand old Livingstone predicted that it would one day "become a nearer India for England." It is, as Livingstone and the other splendid men, whose names now make up the magnificent roll of African travellers, have shown us, a good land, surpassingly rich in animal, vegetable, and mineral wealth. It is a land of great lakes and rivers, forming natural highways for commerce. The population is estimated at from 200,000,000 to 400,000,000. Here are the materials. What more, as a commercial community, can we ask, to create, in a very few years, a trade which would ensure the future of English industries for at least the next hundred years? I ask my fellow-countrymen—shall we rise to the grandeur of the opportunity which God has provided in this our hour of extremity, or shall "Ichabod" henceforth be written over the name of England? If we shirk this great mission, some other nation worthier than ourselves will take our place. No Englishman, be he peer or peasant, can say, "Africa does not concern me." The present chief outlets for Lancashire are India and China, but these we are largely bound to lose—where, then, can we turn to, but Africa? The following will show the practically illimitable field for trade which Africa offers. India has a population of some 250,000,000, and to them England exports annually about 1,200,000,000 yards of cotton goods, the manipulating of which gives employment to some 200,000 mill hands, mechanics, warehousemen, clerks, porters, and others; but India only takes from us half of what she consumes, the other half being the product of her own hand-looms, the total of India's consumption of cotton goods thus being 2,400,000,000 yards annually. Assuming the population of Africa to equal that of India, and being a non-manufacturing continent, Africa should, in process of time, take double what India now takes from us annually. "Verax," or Mr. Dunckley, of the *Manchester Examiner and Times*, has given it as his opinion that, if I suppose that, man for man, the African will consume as much as the Hindoo, I am much mistaken, because, says "Verax," the Hindoo, as a result of his ancient civilisation, requires to be more completely clothed than the savage African. If "Verax" had travelled through India, he would have been aware that the children of the poor, who form the majority, go about entirely naked, and that the adult male labourer has commonly no more clothing on his person than may be represented by a large pocket-handkerchief. Why has Indian civilisation not done more for the cotton trade? Simply because wave after wave of invasion has swept over India, the people have been ground down by the exactions of tyrannical rulers, leaving India an impoverished country, and her people too poor to dress. The African, it is true, is a barbarian, but he lives surrounded by rude plenty, his country teems with natural wealth virgin from the foundation of the world, of the value of which he is, as yet, ignorant. Give him the opportunity of bartering the products of his country for our manufactures, and, man for man, I think it will be found that the African will consume more clothing than the Hindoo. Lancashire may regard with calmness the gradual loss of her Indian trade, if she at once puts forth her best efforts to find a substitute in Africa. Assuming that what is herein stated be in the main correct, the question naturally comes, what is the best and speediest plan for opening out Africa to trade on a large scale? Following the example of the East India Company, I would commercially invade the country from all points which are practicable, concentrating chief attention on those routes which will most speedily admit us to the great interior centres. I would place a fleet of suitable steamers to tap the Niger and Livingstone rivers and their tributaries, and simultaneously commence a railway from a convenient point on the Zanzibar coast to the Victoria

Nyanza lake, a distance of some 500 miles. Mr. Stanley informs us—and others substantially confirm his statement—that the country through which this line would pass is one of easy gradients, and that there are no engineering difficulties to speak of. According to Mr. Stanley, this railway, when made, would introduce us to regions containing 30,000,000 of people, willing to take cotton goods, woollen blankets, Birmingham and Sheffield ware, and other articles, and give us in exchange cotton, rice, splendid grain, coffee, oils, gums, valuable furs, orchilla weed, timber, india-rubber, ivory, and other products. The journey at present requires five or six months from the coast to the Victoria Nyanza lake; the railway would traverse the distance in 48 hours. All merchandise is now carried on men's heads, and, consequently, on articles sold at the lake 800 per cent. is placed upon the cost at Zanzibar. Mr. Stanley says the return traffic on the railway would be very heavy. He states that cattle can be bought at three to five dollars a head, and would sell readily at Zanzibar and along the coast for 15 to 25 dollars each. Goats and sheep can be bought at half a dollar to a dollar, and would sell at the coast for five dollars; splendid grain can be bought five bushels for a half dollar, and would sell at half a dollar per bushel; Usongora coffee can be bought at two dollars per cwt., and sells in England at 110s. per cwt. As Sir Samuel Baker has remarked, what would it avail if you had a mountain of gold in these districts, and had no means of transit to the coast; but open the railway, and you open a modern Ophir to the trading community of England. The 500 miles of railway could be made in 18 months, all the materials being procured in England, at a cost not exceeding £2,000 per mile; but, on this point, I believe there are eminent engineers present who will perhaps give us information. The railway completed, would convey large and small steamers in sections for navigating the 21,500 square miles of water of the Victoria Lake, and the navigable rivers connected with it. It is safe, I think, to state dogmatically that, where a large trade can be developed, and water transit is not available, the next cheapest transit is the railway, and once the Zanzibar and Victoria railway comes into successful operation, a vista of railway development is opened, in the then no longer neglected continent, which would gladden the souls of railway contractors, engineers, makers of steel rails, colliery and iron-mine proprietors, and railway people generally, because the next inevitable step would be link railways, connecting Lake Victoria Nyanza with Lake Tanganyika, Tanganyika with Lake Nyassa, Nyassa with the Rivers Shiré and Zambesi, and once there, the progress of events will force the future Transvaal railway to creep northwards, until a junction is made with the link railway referred to. Many will say this is a dream of a possible future. Its realisation is, in my opinion, an inevitable necessity for the commerce and increasing population of England; but to return to what is immediately possible. I have indicated the three chief points of attack, the Niger, the Livingstone, and the Lake Regions, to be approached from the East Coast by means of a railroad. For the simultaneous utilisation of these, a capital of no ordinary dimensions is requisite.

The Zanzibar Railway would cost at least..	£1,000,000
A railway 200 miles would be required to get past the cataracts on the Livingstone, costing	400,000
Steamers on lakes and rivers, wharves, warehouses, trading stations, another....	2,000,000
A trade proportioned to such transit facilities, and consisting entirely of barter, would lock up a large capital, inasmuch as the manufactured goods sent out from England could not be converted into cash until returns in the shape of produce were brought home and realised, which would be a period of nine months, therefore, the working capital I estimate would have to be	3,000,000
Total..........	6,400,000

But, as a common cause of failure in many really sound commercial undertakings has been insufficiency of capital, an enterprise of such pith and moment as throwing open the Continent of Africa to trade, should be carefully protected against such a contingency. In the development of this great work, unforeseen difficulties must be provided for at the outset, and a reserve of capital should be kept available to meet such difficulties, should they arise. I would therefore advocate the formation of an African Corporation, with a capital of £10,000,000, with limited liability to shareholders, and make the first call one-fifth of the amount, or £2,000,000 sterling, the balance to be called up as requisite. I would have shares of £1, to enable the working classes to be interested, and thus secure shareholders and supporters all over England, Ireland, and Scotland. I should regret to see the concern vested in the hands of a few great capitalists, as this would result in monopoly and retard development. I would much prefer to see, say, 50,000 shareholders, whose holdings ranged from £1 to a few thousand pounds per individual. This would create and sustain a national interest in the work, and in the event of the moral support of the English Government being required from time to time, all reasonable requests made by such a body of shareholders would receive from the Government of the day respectful consideration. Although the proposed railway would belong to the proposed corporation, the world at large should be allowed to use it, at a fixed and reasonable tariff. At the same time, arrangements should be made that for a given number of years no competing line should be made, until the first adventurers had received reasonable compensation on the money they had risked in an untried undertaking. Some are taken aback at £10,000,000, and suggest a few hundred thousands as a beginning, which means that trade operations are still to continue restricted to the coast, which coast trade has existed for centuries. To do the work effectually, we must have a modified East India Company—able to make roads, and equal to removing the obstacles which have hitherto kept the interior centres of Africa a sealed book; and able to protect everywhere persons and property, whilst bringing the blessings of security and civilisation to the tribes with which it comes in contact. Any scheme, or schemes, short of this will fail to bring in time that relief to the waning industries of our country which is needed to save them from

extinction. £10,000,000, relatively, is only a small sum. Consider the little corner of Africa called Egypt. How many tens of millions have been found for that country, and with what small benefit to English industries? Consider the hundreds of millions wasted on Turkey, Spain, and South American republics. Are £10,000,000, then, too great a sum to raise, to rescue a whole continent from darkness; to provide employment for a century to hundreds of thousands of our working men and women; to secure an ample and healthy outlet for the rusting energies of our young men of the middle and upper classes; to retain hundreds of millions' worth of property in England, at a value of 20s. in the pound; and to end at last the slave traffic which has blighted Africa, and been the bane of Turkey, and which, in its turn, is such a source of anxiety to the world, and England in particular. The commercial world is greatly distressed on the bullion question, gold is becoming too scarce and silver apparently too abundant. I think it probable the complete opening out of Africa will solve this difficulty. Gold exists almost everywhere in Africa, and with the development of the country, African gold will make up for deficient yields from the sources of supply upon which the civilised world has hitherto depended, whilst railways, roads, and steamboats in Africa will create a necessity for silver coin, the demand for which will gradually absorb the present surfeit of silver, which for some time past has been a prolific source of loss to the mercantile community engaged in foreign exchange operations.

I have chosen the cotton trade for a text as being the leading industry of the kingdom, and as the one with which I am most conversant; but I believe that the line of argument I have used, as to the necessity there is for the cotton trade seeking a substitute in Africa for the markets which it is losing elsewhere, is equally applicable to the woollen, iron, and hardware trades; and upon these leading industries depend all the minor industries of the country, which contribute to our daily needs, or administer to our comforts. Africa, whether considered religiously, philanthropically, commercially, or politically, must now be heard and attended to—her time has come, in the world's hour of need, and according to the measure we mete out to Africa, it shall be measured to us again. Let us, as a Christian and the leading commercial nation of the earth, use faithfully the talents entrusted to us. Let us freely give our capital of energy and money to Africa, and it will come back good measure, pressed down, shaken together, and running over into the national bosom.

DISCUSSION.

Mr. Fell said:—Mr. Bradshaw, in his comprehensive and valuable paper, has laid before you a scheme for opening up a trade with Central Africa by means of steamers on the Rivers Niger and Livingstone, and of a railway from the Coast of Zanzibar to the Lakes Victoria, Nyanza, and Tanganyika. The proposed railway, combined with steam navigation on the lakes, he has told the meeting, on the authority of Mr. Stanley, would place us in communication with thirty millions of the people of that dark continent for the purpose of carrying to them the benefits of commerce, civilisation, and Christianity. The railway would be 500 miles in length, could, he says, be made in 18 months, and at a cost of £2,000 per mile. It will scarcely be necessary to show that Mr. Bradshaw is right in having assumed that communication by railway is the very foundation of any plan for opening up a trade with the lake regions of Central Africa, because, in fact, no other known method of transport for this purpose is practicable. The present insignificant amount of traffic carried on by the natives in loads of about 60 lbs. by each man, costs, I am informed, as much as £140 per ton between the coast and the lakes. With such an excessive cost of transport, ivory and gold are the only articles that can be sent down to the coast for exportation, and Manchester cloth, beads, and brass wire, in small quantities sent up into the interior, the cost of carriage amounting to seven or eight times that of their original value. Transport by horses or oxen is impossible, because there are no roads, and if roads were made, animals could not live on account of the attacks of the *tsetse* fly. The African elephant has never yet been tamed and made available, like the Indian elephant, for this service, and even if this could be done, it would be a means of transport, as regards expedition, capacity, and economy, vastly inferior to that of a railway. It is, therefore, evident that, for the purpose of opening up a large and profitable trade with the upper lake regions of Central Africa, a railway is an absolute necessity. That a railway from the coast of Zanzibar into the interior can be made, probably no one will entertain a doubt, but doubts have been expressed as to whether this railway can be made at the cost and in the time represented by Mr. Stanley and Mr. Bradshaw; and unless it can be shown that this is practicable, or at any rate that a railway can be constructed for a sum much below the average cost of railways in India, or in the Cape Colonies, the scheme for opening up a trade with Central Africa may never be carried out, and both England and Africa may lose, at least for our time, the immense benefits both countries would derive from a rapid and cheap means of communication being established between them. The engineering problem to be solved, therefore, is whether and how a railway of 500 miles in length can be made at so small a cost as to render the scheme financially and commercially possible. We are told by Burton, Stanley, Cameron, and other travellers, that the general character of the country is favourable, that the works would not be heavy nor the gradients steep. But on the other hand, there are special difficulties to be overcome, inasmuch as there are no roads or means of transport except by native carriers, and there is little or no available labour to be obtained in the country, as the Central Africans will not work. On some parts of the line traversed by the proposed railway food can hardly be obtained, and water is scarce. These are serious difficulties, which will have to be considered and provided for in any plan adopted for the construction of the railway, or otherwise both the cost and time of construction might very much exceed those named by Mr. Bradshaw. One method by which these difficulties could be successfully overcome would be by commencing the formation of the railway at the Zanzibar coast, and advancing into the interior by working from one point only. By this arrangement all the necessary supplies of materials, labour, and food could be brought up from the base of operations established on the coast, and the regularity of the supplies made certain. To make a railway, however, of 500 miles in length by working from one point only, would require, by the ordinary method of construction, an indefinite period, more like 18 years than 18 months, for its completion. This difficulty can, I believe, also be overcome, and the railway be made at the rate of one mile, or, if desirable, even at the rate of two miles per day, consequently the whole line could be finished and opened for traffic within 18 months or two years of its commencement, and at a cost, supposing the country to be as described, of not more than from £2,000 to £3,000 per mile. As

the Committee of the African Section of the Society of Arts has been pleased to give an evening next month, for considering the question of the best method of making a railway for carrying our trade into Central Africa, and have given me leave to read a paper on that occasion, I will not occupy the time of the meeting longer than to give a few of the general features of the plan, or method of construction, I would recommend as best adapted for penetrating into the interior of the dark continent of Africa. I should propose the construction of a light, narrow gauge railway of not less than two feet six inches, or more than three feet six inches gauge. Earthworks and masonry would, to a great extent, be dispensed with, and a light wrought iron structure, affording continuous waterway for the free passage of the heavy tropical rains, would be substituted for them, and used in their place. This railway would be capable of carrying a traffic of 1,000 tons in each direction per day, and the trains would travel at a speed by which they would perform the journey from the coast to the Lake Victoria Nyanza in two days, instead of from three to five months, as is the case at the present time. If a railway can be made satisfactorily to fulfil all these conditions —and I believe it can—this fact once clearly established will go far towards proving the feasibility of the great scheme Mr. Bradshaw has had the honour of laying before the Society of Arts this evening. One other remark I would make with respect to the construction of a railway. Some years ago, I was struck with the idea of making a railway with one single rail, and I took out a patent for it, and experimented on it in the North of England; but I found there were certain inconveniences connected with it; the friction was very great, and there was a tendency in the upright posts to get out of the perpendicular, and, altogether, the results were not so good as with a narrow gauge railway. I found that the same idea had been taken up by Mr. Palmer, one of the early presidents of the Society of Civil Engineers, who patented it, and constructed a line about a mile and a half in length, near Cheshunt, which was used for carrying bricks; but it was not successful, and was taken up. Therefore, a single-rail line, although apparently more simple, does not answer so well as a double line. I am aware that Mr. Haddan is of a contrary opinion, and, if he can make a single rail do more than has ever been done by two, all honour to him; but there is an old saying, that seeing is believing, and I shall not believe it until I see it.

Mr. Howard said he had been deputed by the working men of Preston to attend that meeting, being a working man himself. For the last 40 years they had never known the cotton trade in such a sad state as it was at the present moment. Thousands of spindles were standing idle, and thousands of looms were doing nothing, whilst millions of capital were producing no interest. They had been looking anxiously for some time for some one to come to the rescue. There was no doubt that the markets were overstocked, and that more cotton goods were being produced than those who purchased them could take. America, France, Russia, and other countries were all learning to produce their own goods; they were therefore compelled to look for a new market, and no place seemed to promise better than Central Africa. It became a matter of interest to all Englishmen to take the question up in earnest, and assist Mr. Bradshaw and those working with him. All seemed to agree that Africa was a great market, and they only differed as to where to begin; some said the west and others the east, and it appeared to him, from what had been said, that was the proper side.

Colonel Grant said he was only acquainted with a portion of Africa, viz., the region that extends from Zanzibar round by the south of the Victoria Lake and up through Egypt. The currency in use varied in different parts of the country; near Zanzibar it consisted of Venetian beads, iron, copper, and cotton—mostly American—and coloured cloths. Getting farther north, the articles varied, the tribes more inland were more scantily clothed than on the coast, and there was a demand for cotton cloth. On the top of the hill range they were very keen to trade, and they were rich in coloured cloths, mostly Indian. After passing them, you came to the tribes who had been accustomed to trade with Zanzibar, taking down ivory and exchanging it for cloth; and if a railway could reach them, no doubt a good trade could be done. Beyond that district there was no demand for cloth except amongst the chiefs, the people wearing skins or cloth made from bark. Further north still, you came to a people who wore no clothing whatever, and then you approached Egypt, and the region of civilisation and clothing again.

Mr. Haddan said it was quite true that everybody was now trying to produce for themselves, and that was the worst thing which could happen to us. The reason was very simple; we lent other countries money to do things which they would not put their own money into, such as railways, which had not paid a sixpence for the last five or six years, and the people used their own money to compete with us in manufactures. It was no use adding up exports and imports unless you included the money exported. He had been ten years in a wretched country, where he did not even get straw to make bricks with, and was brought down to the level which all would have to come to before they could make money out of Africa. Everybody took it for granted that a railway would not pay, simply because engineers said so. The weak point of all railway calculations was reckoning by the mile, but a railway calculated by the mile was the most delusive comparison you could have. A railway might be made in a straight line from point to point, but it would be so expensive that it would never pay. You could not get over this fact, that the maximum gradient for economical working with a locomotive was 1 in 300, as long as you went on the principle of getting your tractive force by concentration of weight in the engine. Mr. Fell's railway was only an ordinary railway, put up in the air in order not to interfere with water-courses, which was a great thing in a tropical country, but, with the old-fashioned plan of concentrated weight, it was no wonder if it did not answer. His plan was similar to the continuous brake—a continuous motor, which enabled every carriage to go by itself; and you could then run on gradients of 1 in 7.

Mr. Morrell said he was not specially interested in cotton, but in coal, iron, and railways; but there could be no doubt it was a matter of national importance to open up new markets somewhere. He had recently been told that in South Staffordshire there were only 23 blast furnaces at work out of 149. America and India were beginning to manufacture for themselves, but in Africa there was a great continent which had hitherto been neglected. They could scarcely tell yet which was the best mode of proceeding; no doubt if they could find means of water carriage that would be the best, but except, perhaps, by the Niger, Africa could not be entered in that way. The next best means was a railway, and though the people were frightened when you spoke of a railway, it was because they immediately thought of one like the London and North Western, but engineers told us there must be a system of light and economical railways. With regard to the point of approach, he thought, on the whole, the East Coast was the best.

Captain Foot R N., said the last opportunity he had of speaking in the room, was when Commander Cameron read a paper there, and though the good cause had not progressed so fast as could be desired, they need not be discouraged. From the way in which attention was now being directed to East Africa, it seemed to be the general impression that was the right place to

begin. He had been on the West Coast, and up nearly all the rivers; the first expedition up the Niger was in 1862 or 1863, and since then numerous steamers had gone up, at first guarded by a man-of-war, but now they were allowed to trade in comparative peace. From what he knew of the West Coast, he thought they must leave the trade there to be developed by those who were in possession. The oil rivers were occupied by merchants mostly connected with Liverpool or Glasgow, but if an opportunity arose for opening up the country more to general trade it should be embraced. The existing treaties were made more for the purpose of extinguishing slavery than for developing trade, and he hoped some means would be adopted for altering these treaties, and allowing British produce to be pushed further into the country. He had been interested in the development of Africa for some time, and was very pleased to see that so much attention was being paid to it. The Sultan of Zanzibar was anxious for the development of the country, and he was quite convinced that if England would take the matter up it would be to the benefit of commerce generally, and not to the cotton trade only. Foreign nations were beginning to move in the matter; the Italians were doing something, and Colonel Gordon was doing good work in the Soudan. Unfortunately, we were at war in the south, but he trusted that that difficulty would be settled peaceably ere long, and that trade would increase. The suggestion had been made that elephants should be used in the trade on the East Coast, and he hoped that every encouragement would be given to this idea.

Dr. Mann read a communication from Mr. H. B. Cotterill to the following effect:—I am sorry to say that I cannot possibly manage to be present at the meeting on the 18th; but shall be very glad if you will allow me to contribute the following remarks on the subject of Mr. Bradshaw's communication. (1.) With regard to the demand for cloth in Africa, it is, as Mr. Bradshaw says, altogether unreasonable to institute a comparison between the Indian and African native with the idea that the former, on account of his more civilised habits, would require a greater amount of clothing. In the first place, as may be seen in Elton's descriptions of our experiences among the Wa Chungu, tribes which, from the time of Adam, may have been in a primitive state of nudity have at least an "innate idea" of clothing. When they once discover the use of the article, a complete *furore* sets in for the new fashion. The amusing story, told by the German poet Wieland, of an Egyptian priest who experienced this some thousands of years ago, is perfectly true to nature. Unfortunately, in his case, the introduction of clothes brought in its train all the vices of civilised nations—a catastrophe that I trust will not follow in our case. Moreover, the ordinary natives (the coast natives or those of the Zambesi, &c., who have been in contact with the clothes-weaving world) are by no means content with the usual working attire, a piece of linen round their waist. They hoard up calico, not merely in order to make a grand appearance on special occasions, but for the purpose of barter. With it they buy land, food, cattle, and wives. It is the current coin of the realm. To keep up this cloth currency is a point to which we should attend. While it exists, while all labour is paid in cloth, and it is the medium of barter also, we shall have a very much larger demand for it than if ordinary money should be introduced. (2.) I think every African traveller will agree with me when I say that—whatever amount of capital may be forthcoming—one or two schemes of moderate dimensions, well planned and vigorously carried out, will do more towards effecting our object than vast and vague proposals. *Chi va piano va lontano:* slow and sure—that is the maxim for African travel and African schemes. Much as I should like to see a railroad across the malarious belt of country near the coast up to the higher regions, or even to the Nyanza, I cannot but think that we ought first (or at all events simultaneously) to devote our energies to opening up that magnificent waterway which extends up the centre of the continent, from the Zambesi to the line, with only two short breaks. With a rail or tramway across the 50 miles of the Murchison cataracts, another from the north-east of Nyassa to Tanganyika—a distance which the natives of that region told me it took about eight days to traverse with loads—probably some 160 miles—we should have a line of communication about 1,500 miles in length—a line which would intercept all the great trade routes from Central Africa to the East Coast, with the exception of that from Uganda. It would also lie, through by far the greatest part of its whole length, in the midst of regions capable of colonisation, and rich in yet undeveloped resources. Especially with regard to the ivory trade is such a route far preferable to a land route. Ivory takes time to collect. A single steam tug would carry a load representing a large expense of time and money. A constant and rapid means of transport is not necessary; and, considering the great value of iron in proportion to its bulk, a railway would be of little use. I say this, because I believe that ivory is the only product the export of which will prove profitable for some years to come. In short, if my experience as the first white man who attempted to trade on any of the great inland seas of Africa gives me any claim to express an opinion, I believe that we should undertake this, as our first attempt. To lay rails, or open roads, across the country (50 miles) of the Shiré, and across the 160 miles between Nyassa and Tanganyika; and to place a steamer (costing about £2,000) on Nyassa and another, which could be without difficulty taken across from Nyassa, on Tanganyika. Two gentlemen have already gone out with the idea of trading on Nyassa, and have placed a flat-bottomed vessel on the lower river (I trust that by now it is actually on the lower Shiré). Any company that may be formed should act in concert with them, and at once send out two steamers, in sections, for the two great lakes. (3.) I would, lastly, once more call attention to the question that I have already mooted before the Society, and which certain gentlemen, well qualified to speak on the subject, have brought before the public by letters to newspapers—I mean the question of using elephants. There is no doubt that, especially for the ivory trade, long journeys will still have to be made into the remote interior. The natives will not at once bring ivory to our trade centres. For such journeys—and for transport to the coast—I should be exceedingly glad to see employed some of those great idle fellows who roam about, wasting their strength on African forests. The importation of a few Indian elephant catchers would, I believe, solve the question in a very short time. As a last word, I trust that a large, if not a chartered, company will be formed, so that it may carry on all transactions with the natives in an open, public-spirited fashion—to the exclusion of private and unscrupulous adventurers, who, by trading on the superstitions of the natives, and supplying them with arms, will inevitably bring us into some such trouble as has arisen in South Africa.

Dr. Geo. Percy Badger wrote:—An attack of bronchitis prevents my going out of doors. I regret this extremely, as I was most anxious to be present at the meeting of the African Section this evening, and to hear the discussion on Mr. Bradshaw's paper. "There can be no doubt that Africa is comparatively a virgin soil, with vast mineral and vegetable resources waiting to be *exploité*, and offering withal a wide field, or mart, for British industries. But, in order effectually to carry out the scheme or schemes, which, I understand, are contemplated to this end, a large capital will be required, and a strong staff of competent local agents, or overseers. As far as the

territories of the Sultan of Zanzibar extend on the mainland, I am convinced that his Highness will offer every facility to British associations; in fact, I very much question whether he would consent to enter into relations with any non-British *entrepréneurs*. At the same time, it will be well for those who entertain these useful projects to bear in mind that his Highness has his weather-eye open in all matters of business, and that he is not likely to close with any scheme which is one-sided, or, in other words, which overlooks his interest and the interest of his people. Philanthropy, he says, is one thing, and business another, and as the projectors of these undertakings are, doubtless, practical men who expect to derive material profit from their outlay and enterprise, it is but fair that he should have his share therein. I have another remark to make which should be communicated to the meeting. I had, in previous letters, informed the Sultan of the meetings at Manchester and Preston, and suggested to him that he should be prepared to consider any overtures which might be made to him respecting the contemplated opening up of his territories by British capitalists. In his reply, received by last mail, his Highness writes:—"Be pleased to tell any of the gentlemen interested in these matters that such arrangements as they propose cannot be effected by epistolary correspondence, and that if they have any plans to propose it is indispensable that they should depute a representative to discuss with me on the spot what they require of me."

Mr. James Stevenson (Glasgow) said he was at one time largely connected with the trade of Manchester, and had therefore had a substantial interest in the business of the evening. He had taken a deep interest in this subject for four or five years, since the Scobel mission began to occupy Lake Nyassa. They were told by Mr. Young that if they would send out calico, it might prevent the chiefs selling their people to the coast, and a trade was soon begun from the mission station with the chiefs around. He proposed that the principal merchants of Glasgow should raise a sum of £10,000 for the purpose of trading in this district. When Mr. Cotterill went out as a visitor to the mission, they gave him a small capital with which to trade, but the most important thing he had to say was, that what he proposed had never been carried out very fully. There was now established the Livingstonia Company, which had steam launches for 800 miles from the mouth of the Zambesi up to the head of Lake Nyassa, and they had made a road past the cataracts of the Shiré. It might be interesting to know that this road was estimated to cost £10 a mile in rough country, and £5 a mile in smooth, and he found, from a report he had lately read, that this estimate was not likely to be exceeded. It was not a very grand road, but it was from 4 ft. to 10 ft. wide. They had an able engineer there, Mr. Stewart, who laid out the road. They began with 4 ft., and if he found it was a good gradient he afterwards increased it to 10 ft., and thus they paved the way for a tramway, which he hoped would be made in a short time. The Livingstonia Company had five or six central trading posts on the rivers and the lake, and from these they intended to exchange Manchester goods with the natives. At present there was little but ivory produced, but he had no doubt that india-rubber would soon be collected, and cocoa, tea, &c., were already beginning to be planted and grown, which would form freight for these vessels. An exploration was just ordered from Lake Nyassa to Tanganyika, and probably a road would soon be made connecting their station with that of the London Missionary Society. There need be no fear that their operations would be carried out energetically, for there were in Scotland three million people who were all interested in this missionary operation. He doubted whether colonisation was likely to answer, for the country was pretty well peopled, and the Zulu race existed there to a considerable extent, and other races even more warlike, so that very likely if anything of the kind were attempted, they might get into an awkward position. He had published a pamphlet, which would be distributed to those who liked to take a copy, containing a history of the first three or four years of the work, and the programme proposed, which was now pretty fairly completed. He understood that the railway in South Africa to the copper mines cost £1,000 a mile. The people in the part of the country he had referred to were very straightforward and honest, as was shown by the fact that the whole of one of the steamers was carried over 60 miles, and not a nut or bolt was missing. They had, therefore, to be exceedingly careful that the goods they sent out were all genuine and well packed. A friend of his said to him that they ought to get American goods, but his idea was that they ought to get their goods in Manchester. Cotton cloth was the money of the country; they paid all the wages for making the road in so many yards of cloth. At the head of the lake, he was sorry to say the people still wore nothing but paint, and he feared that there white paint would be the best export; but no doubt that would change, and in a short time they would find that calico was more comfortable than paint or even bark cloth. He had no doubt that this trade, although now small, would rapidly develop, and become an important item in the exports from England; but time was required, and great care must be taken not to get into hostilities with the people. Livingstonia was situated in the very focus of the slave trade, but although many people who had run away from the neighbouring chiefs came and settled there, they had hitherto avoided any collision, and he believed there was only one chief who had shown himself at all sulky. He thought this example was not without importance, and might be followed in other parts of the African continent.

Dr. Mullens (London Missionary Society) said he came rather to hear than to speak, in the hopes that some practical scheme which might be speedily entered upon would be brought forward, so as to make intercourse between England and the natives of this part of Africa more close than it had yet been.

Mr. Hutchinson thought the time was come when something must be done, and he had hoped to hear some practical scheme suggested, but he must say that he had heard nothing yet to lead to the belief that a practical direction would be given to these various suggestions. Mr. Cotterill seemed to have hit the nail on the head, and he ventured to think that there was nothing likely to come out of East Africa of a remunerative character for a considerable time but ivory. For more than two years his society had had men who had traversed the Unanyembi country up to Lake Nyanza, and had pretty well examined the south-western and northern shores of the lake, and the most recent despatches led him to the conclusion that there was very little in that part of Africa worth export save ivory. As to constructing a railway, and sending in ten million bales of Manchester goods, it must prove unproductive unless you could bring back something which would be marketable in England. Mr. Bradshaw spoke of splendid grain and coffee, and one or two other things, but he ventured to think that they would not pay the cost of carriage, even by railway. His conviction was that it would take a long time before they would see a development of Africa as they all hoped for. The line to be followed after all seemed to be what he had laid down in the papers he had read there on former occasions. There was no doubt that English capital could be usefully employed on the East Coast, but it must be in connexion with the Sultan of Zanzibar in developing and strengthening his own dominions. Looking to the present distress, and the necessity for finding fresh markets for our productions, he thought they were mistaken in neglecting West Africa, in running so much after the eastern

portion of the continent. There were large districts within easy reach of the River Niger, which were much more likely to take Manchester goods, and other English produce, than Eastern-Central Africa would be for a long time. Not long ago, he sent some fancy soap, and other things, to the Emir of Nupe, whose capital was at the junction of the Niger and the Chaddah; his master at once sent to demand a share, and they sent him back, in return, cotton goods manufactured on the spot, far better in quality than Manchester goods, ivory, and various other little articles. If you turned to the travels of Gerard Rohlfs in the countries of Bornou and Wadai, it would be found that the products of that country were just what would find a sale in the English market. They were very anxious to receive English produce, and, by the Niger and its affluents, there was easy access to the country. The population of that country were far more civilised, and more likely than the tribes farther east to take English manufactures, and in fact they obtained some now through Tripoli and across the Great Sahara. In connection with their own missionary work on the Niger, they had supplied their agent with a small steamer, which had proved to a certain extent a success, and they had received some hundreds of pounds for the carriage of merchandise. He could not hope for any commercial return for money expended in developing Central Africa in the way suggested. The best direction, in his judgment, which the present movement could take with regard to Eastern-Central Africa, would be to assist the Sultan of Zanzibar in affording protection, means of transport, and assistance in various ways to those who wished to penetrate into the country. But much would be accomplished if, as a result of this meeting, the Government were induced to take a broader and more sustained interest in the opening up of Central Africa, both West and East, to English manufactures and commerce.

The Rev. Horace Waller thought when Mr. Bradshaw's enthusiasm in this matter had lasted as long as that of some other friends of Africa, he would find he must really come down from his large figures and great continents, and these benefits to the human race in general, and to Manchester in particular, to what one might call the absolute hard working practical sense of the question. He did not wish to disparage what he had said, but there were certain points thrown out by various speakers which he would do well to attend to. He could not agree with Mr. Hutchinson with regard to the futility of efforts in Central Africa. A greater man than any in that room, and a more practical man, namely, Dr. Livingstone, had always pointed out that there was one way into Africa, and one way of opening it up for commerce, and as a consequence of his opinion had arisen the project of which Mr. Stevenson had spoken. He saw that although missionary enterprise must eventually be everything, there was no chance for its getting a hearing until peace and quiet was established. To this end he devoted his whole fortune and his life, and following in the lines he laid down, Mr. Stevenson had been successful in opening up the Nyanza, and the great waterway into Central Africa. He did not think it would be a failure, and congratulated Mr. Stevenson most heartily on the success which had so far attended him. He had spoken of the honesty of the people, and, knowing something of Africa, he could say you could travel for a hundred miles with nothing but an umbrella, and there were thousands of people who would no more think of robbing a bale of goods of a pound of beads than flying, and, even if they did, there was enough law and order on the spot to bring them quickly to justice. All this had taken a time, however. Livingstone's influence began it, and it had been continued by other men whose bones now laid buried there. Another point of great importance was this, when he was in Africa the death-rate was something frightful, but they had now gained experience, and, being able to reach the healthier parts of the country, the higher ground, they now got letters from Livingstonia, in which the mention of sickness was extremely rare. He had just read 40 or 50 pages of letters with not a mention of health in them from beginning to end. He agreed with Mr. Hutchinson in one thing, that in the interior near to Zanzibar there was neither law, order, nor responsible chiefs. You got your caravans robbed and your bearers murdered. But he did not think the day for railways was yet come, and the hint given by Mr. Cotterill should, he thought, be followed, of introducing elephants. They knew the Carthaginians had fine studs of elephants in olden days, which entered largely into all their military operations, and these must have been African elephants. The practical point, after all, was to keep their eyes fixed on the rift already made in the log on that great waterway, which Livingstone, with the eye of a General, saw was the inlet to Africa. To tell the truth, he wanted to see one plan of procedure squared off against the other. It had taken many years and thousands of pounds to make the Portuguese see it was to their benefit to throw open their ports, and they only did so at last because they feared that commerce would go by way of Zanzibar. Let business and philanthropy be kept separate, and they might easily put a little wholesome pressure on both these two powers, if such they might be called. The head of the lake should be their starting point, and although no doubt ivory would be the great thing to pay for some time, from what he knew of the country he, nevertheless, believed there was a larger future for it. He would venture to repeat a suggestion he had made there once before, that the Society should offer a reward to any native who would produce a tamed elephant to one of the English consuls on the East Coast.

The Chairman remarked that, in Captain Elton's interesting journal, there was an account of a tame African elephant being sent as a present in 1873 from Zanzibar to the Governor of Bombay.

Mr. Briggs thought it was not necessary to go so far from home as Africa in order to open up trade, to remove the oppression from which England was at present suffering, not that he wished to disparage the project by any means. He had some money invested on the West Coast of Africa, but, from letters he had, it appeared there were great difficulties in carrying out trade there, owing to the excessive competition of merchants.

Mr. Edgar regretted he had not been in time to hear the paper. He had seen a letter of Mr. Bradshaw's in the Manchester newspapers. The things which struck him most were the large amount of capital he wanted; secondly, his use of the term national as applied to the enterprise; and, thirdly, the conclusion he had evidently come to, that any other scheme than his own was not national. He regretted that Mr. Bradshaw should have taken that line, because he thought it would need all the agencies which could be brought to bear on this work to bring about the results so much desired. His own feeling was that the scheme was a wild one—not founded on sufficient information—and the arrangements were not based on data which would warrant such an outlay of such a large sum of money. He had no doubt the result would be disastrous to those who invested their money in it. Their desires as patriotic Englishmen would lead them all to wish for a good field for British manufactures, and it appeared that Africa might absorb a great amount of our produce; but a great deal of the hopes held out were due simply to ignorance and want of information. He had conversed with Captain Cameron, and had read a great deal about Africa, and his opinion was that if anyone tried to carry out such a vast plan the

immediate result would be disastrous, though others who came afterwards might reap the benefit. The paper from which the last speaker had quoted, was one he had felt it his duty to issue, because on the Niger the markets were absolutely overstocked, and the merchants were doing their best to cut each other's throats. If that was the case there after the experience of twelve or fifteen years, he fancied pretty much the same kind of thing would occur on the East Coast. He should have liked to have heard from Mr. Stevenson some more details as to the commercial success of the Livingstonia Company. The sum and substance of his remarks would be that, although it was very desirable indeed to open up Eastern Africa, it must be done cautiously, and after a more thorough investigation.

The Rev. Mr. Fowler said there were only two ways of opening up Africa, which he could recommend. One was the use of trained elephants, because he was perfectly sure it would be utterly impracticable to cross over the Massai country, which was occupied by a hostile tribe, and the other way was this. He had been living for the last four years in Eastern Africa, and the people of one of the tribes there had several times requested him to accept the chieftainship. Of course he could not do so, but he could guarantee that if any wise, sensible Englishman went out there, he might very soon be elected, and he could then introduce a civilised government and open up the country.

Mr. Bradshaw, in reply, said he hoped that meeting would form one link in the chain which would bring England and Africa more closely together. He should not attempt to reconcile the various opposing views which he had heard. A good deal had been said by gentlemen who had been in Africa—not commercial men, but clergymen and others—with regard to the use of elephants. He did not at all deprecate that, and thought it highly advisable to use them; but how many elephants would it require to convey, from any point of the coast to the Lake District, a cargo which you could put on 20 trucks drawn by a locomotive, and what time would it take? Why, goods conveyed on a railway would be almost worn out by the time the elephants reached there. A gentleman largely interested in the Zanzibar trade had recently told him that the great difficulty they had was to get a return freight, and that when he went down to the coast early in the morning, to see what Arab dhows had come in, he always found Europeans there anxiously looking out for the same thing. It was not that there was no produce in the country, but there were no means of transit. As Sir Samuel Baker had said, if you had a mountain of gold in the interior, but no means of bringing it to the coast, it would be useless. This coasting trade had existed for the last two or three thousand years on the East Coast, and for several centuries on the West, and it appeared to him the view advocated by most of the speakers went to show that they should go on for two or three centuries more at the same rate they had been going in the past. But where would Lancashire and the industries of England be unless they could travel at a greater speed. They could not expect that Africa would come to the salvation of English commerce unless they were prepared to spend money upon it. His friend, who was connected with Zanzibar, urged upon him the necessity for a railway, that nothing else would be equal to the requirements of the trade; but, above all, it would be necessary to have abundance of capital to begin with. All other subsidiary measures, such as elephants, were not worth talking about as compared with the railway. Stanley said there were round the coast of the Victoria Nyanza, which was only 500 miles from the coast, about six millions of people. If there was a population of six millions at Aberdeen not yet reached, we should not be long in making a railway there; and it must be remembered that these six millions were only representative of a much larger number. He had been informed by Mr. Hutchinson that the population of equatorial Africa was estimated to be about 100 millions, and how many of these could you reach by tinkering away along the cost. There was no question about the resources of the country or the population: what was wanted was means of transit, and where you had not water-carriage the next cheapest mode of transit was a railway.

The proceedings concluded with votes of thanks to Mr. Bradshaw and the Chairman.

FIFTEENTH ORDINARY MEETING.

Wednesday, March 19th, 1879; Lord Alfred S. Churchill, Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Bullivant, William Pelham, 72, Mark-lane, E.C.
Emery, Robert, Cobridge, Staffordshire.
Ferreira, Eduardo de Moraes Gomes, C.E., 15, Bedford-place, Russell-square, W.C.
Greenhill, Matthew Cranswick, South Hawes, Southport.
Pescott, Benjamin H., Southampton-hall Literary Institute, 269, Southampton-street, Peckham, S.E.
Stevenson, James, F.R.S., West Nile-street, Glasgow.

The paper read was—

ECONOMIC GARDENS FOR THE MIDST OF LONDON AND OTHER SMOKY TOWNS.

By W. Mattieu Williams, F.R.A.S., F.C.S.

The poetical philanthropists of the shepherd and shepherdess school, if any still remain, may find abundant material for their doleful denunciations of modern civilisation on journeying among the house tops by any of our over-ground metropolitan and suburban railways, and contemplating therefrom the panorama presented by a rapid succession of London back yards. The sandy Sahara, and the saline deserts of Central Asia, are bright and breezy, rural and cheerful, compared with these foul, soot-smeared, lumber-strewn areas of desolation.

The object of this paper is to propose a remedy for these metropolitan measle-spots, by converting them into gardens that shall afford both pleasure and profit to all concerned.

A very obvious mode of doing this would be to cover them with glass, and thus convert them into winter gardens or conservatories. The cost of this at once places it beyond practical reach; but even if the cost were disregarded, as it might be in some instances, such covering in would not be permissible on sanitary grounds; for doleful and dreary as they are, the backyards of London perform one very important and necessary function; they act as ventilation shafts between the house backs of the more densely populated neighbourhoods.

At one time I thought of proposing the establishment of horticultural home missions for promoting the dissemination of flower-pot shrubs in the metropolis, and of showing how much the atmosphere of London would be improved if every London family had one little sweetbriar

bush, a lavender plant, or a hardy heliotrope to each of its members; so that a couple of million of such ozone generators should breathe their sweetness into the dank and dead atmosphere of the denser central regions of London.

A little practical experience of the difficulty of growing a clean cabbage, or maintaining alive any sort of shrub in the midst of our soot-drizzle, satisfied me that the mission would fail, even though the sweetbriars were given away by the district visitors; for these simple hardy plants perish in a mid-London atmosphere unless their leaves are periodically sponged and syringed, to wash away the soot particles that otherwise close their stomata and suffocate the plant.

It is this deposit that stunts or destroys all our London vegetation, with the exception of those trees which, like the planes, have a deciduous bark and cuticle.

Some simple and inexpensive means of protecting vegetation from London soot are, therefore, most desirable.

When the Midland Institute commenced its existence in temporary buildings in Cannon-street, Birmingham, I was compelled to ventilate my class-rooms by temporary devices, one of which was to throw open the existing windows, and protect the students from the heavy blast of entering air by straining it through a strong gauze-like fabric (tammy) stretched over the opening.

After a short time the tammy became useless for its intended purpose; its interstices were choked with a deposit of carbon. On examining this, I found that the black deposit was all on the outside, showing that a filtration of the air had occurred. Even when the tammy was replaced by perforated zinc, puttied into the window frames in the place of glass panes, it was found necessary to frequently wash the zinc, in order to keep the perforations open.

The recollection of this experience suggested that if a cheap, strong, gauze-like fabric can be obtained, and a sort of greenhouse made with this in the place of glass, the problem of converting London back yards into gardens might be solved.

After some inquiries and failures in the trial of various cheap fabrics, I found one that is already to be had, and well adapted to the purpose. It is called "wall canvas," or "paper-hanger's canvas," is retailed at $3\frac{1}{2}$d. per yard, and is one yard wide. If I am rightly informed, it may be bought in wholesale quantities at about $2\frac{1}{4}$d. per square yard, *i.e.*, one farthing per square foot. This fabric is made of coarse unbleached thread yarn, very strong and open in structure. The light passes so freely through it, that when hung before a window the loss of light in the room is barely perceptible, and as may be seen by the piece here stretched upon a frame, a printed placard, or even a newspaper, may be read through it.

The yarn being loosely spun, fine fluffy filaments stand out and bar the interstices against the passage of even very minute carbonaceous particles. These filaments may be seen by holding it up to the light.

The fabric being one yard wide, and of any length required, all that is needed for a roof or side walls, is a skeleton made of lines or runs of quartering, at 3 feet distance from each other. The cost of such quartering, made of pitch pine, the best material for outside work, is under one penny per foot run; of common white deal, about three farthings. Thus the cost of material for a roof, say a lean-to from a wall-top to the side of a house, which would be the most commonly demanded form, of 30 feet by 10 ft., *i.e.*, 300 square feet would be—

	s.	d.
110 feet of quartering (11 lengths), at 1d...	9	2
300 square feet of canvas, at $\frac{1}{4}$d.	6	3
Nails and tacks, say	1	0
	16	5

The size of the quartering proposed, is $2\frac{1}{2}$ by $1\frac{1}{4}$ inch, which, laid edgewise, would bear the weight of a man on a plank while nailing down the canvas. The canvas has a stout cord-like edge or selvage, that holds the nails well.

I find that what are called "French tacks," are well suited for nailing it down. They are made of wire well pointed, have good sized flat clout heads, and are very cheap. They are incomparably superior to the ordinary rubbish sold as "tin tacks" or "cut tacks." The construction of such a conservatory is so simple, that any industrious artisan or clerk with any mechanical ingenuity could, with the aid of a boy, do it all himself. No special skill is required for any part of the work, and no other tools than a rule, a saw, and a hammer. Side posts and stronger end rails would in some cases be demanded.

I have not been able to fairly carry out this project, inasmuch as I reside at Twickenham, beyond the reach of the black showers of London. I have, however, made some investigations relative to the climate which results from such enclosure.

This was done by covering a small skeleton frame of dog kennel shape with the canvas, putting it upon the ground over some cabbage plants, &c., and placing registering thermometers on the ground inside, and in similar position outside the frame; also by removing the glass cover of a cucumber frame, and replacing it by a frame on which the canvas is stretched.

I planted 300 cabbages in November last, in rows on the open ground, and placed the canvas covered frame over 18 of them. At the present date, March 15, only 26 of the 282 outside plants are visible above ground. All the rest have been cut off by the severe frost. Under the frame all are flourishing.

I find that the difference between the maximum and the minimum temperatures varies with the condition of the sky. In cloudy weather, the difference between the inside and the outside rarely exceeds 2 deg. Fahr., and occasionally there is no difference. In clear weather the difference is considerable. During the day the outside thermometer registers from four or five to seven or eight degrees above that within the screen during the sunshine. At night the minimum thermometers show a difference which in one case reached 14 deg., *i.e.*, between 23rd and 24th February, when the lowest temperature I have observed was reached. The outside thermometer then fell to 8 deg. Fahr., the inside to 22 deg. On the night of the 24th and 25th they registered $15\frac{1}{2}$ deg. outside, $25\frac{1}{2}$ deg. inside. On other, or ordinary clear frosty nights, with E. and N. and NE. winds, the difference has ranged between 4 deg. and 6 deg., usually within a fraction

of the average, 5 deg. The uniformity of this during the recent bright frosty nights, followed by warm sunny days, has been very remarkable, so much so that I think I may venture to state that 5 deg. may be expected as the general protecting effect of a covering of such canvas from the mischievous action of our spring frosts which are due to noctural radiation into free space. Thus we obtain a climate, the mean of which would be about the same as outside, but subject to far less variation. How will this affect the growth of plants desirable to cultivate in the proposed canvas conservatories?

In the first place, we must not expect the results obtainable under glass, which by freely transmitting the bright solar rays, and absorbing or resisting the passage of the obscure rays from the heated soil, produces, during sunshine, a tropical climate here in our latitudes. We may therefore at once set aside any expectation of rearing exotic plants of any kind; even our native and acclimatised plants, which require the maximum heat of English sunshine, are not likely to flourish.

On the other hand, all those which demand moderate protection from sudden frosts, especially from spring frosts, and which flourish when we have a long mild spring and summer, are likely to be reared with especial success.

This includes nearly all our table vegetables, our salads, kitchen herbs, and British fruits, all our British and many exotic ferns, and, I believe, most of our out-of-door plants, both wild and cultivated.

As the subject of ornamental flowers is a very large one, and with the cultivation of which I have very little practical acquaintance, I will pass it over; but must simply indicate that, in respect to ferns, the canvas enclosure offers a combination of most desirable conditions. The slight shade, the comparatively uniform temperature, and the moderated exhalation, are just those of a luxuriant fern dingle.

Respecting the useful or economic products I can speak with more confidence, that being my special department in our family or home gardening, which, on sanitary grounds, I have always conducted myself, with a minimum of professional aid.

My experience of a small garden leads me to give first place to salads. A yard square of rich soil, well managed, will yield a handsome and delicious weekly dish of salad nearly all the year round; and at the same rate seven or eight square yards will supply a daily dish—including lettuces, endives, radishes, spring onions, mustard, and various kinds of cress, and fancy salads, all in a state of freshness otherwise unattainable by the Londoner. My only difficulty has arisen from irregularity of supply. From the small area allowed for salads, I have been over-supplied in July, August, and September, and reduced to indoor or frame-grown mustard and cress during the winter. With the equable insular climate obtainable under the canvas, this difficulty will be greatly diminished; and besides this, most of the salads will be improved by partial shade, lettuces and endives more blanched and delicate than when exposed to scorching sun, radishes less fibrous, mustard, cress, &c., milder in flavour and more succulent.

The multitude of savory kitchen herbs that are so sadly neglected in English cookery (especially in the food of the town artisan and clerk), all, with scarcely an exception, demand an equable climate and protection from our destructive spring frosts. These occupy very little space, less even than salads, and are wanted in such small quantities at a time, and so frequently, that the hard-worked housewife commonly neglects them altogether, rather than fetch them from the greengrocer's in their exorbitantly small pennyworths. If she could step into the back yard, and gather her parsley, sage, thyme, winter savory, mint, marjoram, bay leaf, rosemary, &c., the dinner would become far more savoury, and the demand for the alcoholic substitutes for relishing food proportionably diminished.

My strongest anticipations, however, lie in the direction of common fruits—apples, pears, cherries, plums of all kinds, peaches, nectarines, gooseberries, currants, raspberries, strawberries, &c.

The most luxuriant growth of cherries, currants, gooseberries, and raspberries I have even seen in any part of the world that I have visited, is where they might be least expected, viz., Norway, not the South of Norway merely, but more particularly in the valleys that slope from the 500 square miles of the perpetual ice desert of the Justedal down to the Sognefjord, latitude 61 deg. to 61½ deg., considerably to the north of the northernmost of the Shetland Islands. The cherry and currant trees are marvellous there.

In the garden of one of the farm stations (Sande) I counted 70 fine bunches of red currants growing on six inches of one of the overladen down-hanging stems of a currant bush. Cherries are served for dessert by simply breaking off a small branch of the tree and bringing it to the table—the fruit almost as many as the leaves.

This luxuriance I attribute to two causes, first, that in that part of Norway the winter breaks up suddenly at about the beginning of June, and not until then, when night frosts are no longer possible, do the blossoms appear. It was on the 24th August that I counted the 70 bunches of ripe currants. The second cause, the absence of sparrows, and other destructive small birds that devour our currants for the seeds' sake before they ripen, and our cherries immediately on ripening, and the bullfinches that feed on the tender hearts of the buds of most of our fruit trees. Those who believe the newspaper myths which represent these birds eating caterpillars, should make observations and experiments for themselves as I have done.

In our canvas conservatories neither sparrows nor caterpillars, nor wasps, or other fruit stealers will penetrate, nor will the spring frosts nip the blossoms that open out in April. All the conditions for full bearing are there fulfilled, and the ripening season, though not so intense, will be prolonged. We shall have an insular Jersey climate in London, where the mean temperature is higher than in the country around, and, if I am not quite deluded, we shall be able to grow the choicest Jersey pears, those that best ripen by hanging on the tree until the end of December, and fine peaches, which are commonly destroyed by putting forth their blossoms so early. All the hundred-and-one varieties of plums and damsons, greengages, &c., that can grow in temperate climates will be similarly protected

from the frosts that kill their early blossoms, and the birds and the wasps that will not give them time to ripen slowly.

I have little doubt that if my project is carried out, any London householder, whether rich or poor, may indulge in delicious desserts of rich fruit all grown on the sites of their own now dirty and desolate back yards; that if prizes be given for the most prolific branches of cherry and plum trees, gooseberry and currant bushes, the gardens of the Seven-dials of classic St. Giles's will carry off some of the gold medals; and that, by judicious economy of space, and proper pruning of the trees, the canvas conservatories may be made not only to serve as orchard houses, but also to grow the salads, kitchen herbs, and green vegetables for cookery, under the fruit trees or close around their stems.

Among the suitable vegetables, I may name a sort of perennial spinach which yields a wonderful amount of produce on a small area. Four years ago I took the house in which I now reside, and found the garden overgrown with a weed that appeared like beet, the leaves being much larger than ordinary spinach. I tried in vain to eradicate it, then gave some leaves to my fowls. They ate them greedily. After this I had some boiled, and found that the supposed weed is an excellent spinach, which may be sown broadcast in thick patches, without any interspaces, and cut down again and again all the year round, fresh leaves springing up from the roots until the autumn, when it throws up tall flowering stems, and yields an abundant crop of seeds. I have some now, self sown, that has survived the whole of the late severe winter, while turnip-tops, cabbages, and everything else has perished. I have sown the ordinary spinach seed in the usual manner in rows, and comparing it with the self-sown dense patches of this intruder, find the latter produces, square yard against square yard, six or eight times as much of available eatable crop.

If the flowering stem be cut down, the root sends forth fresh leaves even for a second year; but an attempt to grow it in orderly rows, by transplanting, has failed; the young plants, when moved, throwing up seed stems instead of large, spreading leaves. It may be that I transplanted at the wrong season (about June or July last).

None of my friends who are amateur gardeners know this variety; but, a few days since, I called on Messrs. James Carter and Co., the wholesale seedsmen of Holborn, and described it. They gave me a packet of what they call "Perpetual spinach beet," which, as may be seen by comparison with the seeds of those I have here of my own growing, is probably the same. Messrs. Carter and Co. tell me that the plant is very little known, and the seed scarce from want of cultivation and demand. I therefore step so far aside to describe and recommend it as specially suited for obtaining large crops on small areas. I would also recommend a mode of growing cabbages that I have found very profitable, viz., to sow the seed broadcast in beds or patches and leave the plants crowding together; cut them down while very young, without destroying the centre bud; let them sprout again and again. They thus yield a succession of crops, every leaf of which is eatable. This, instead of transplanting and growing large plants, which, however desirable for sale in the market, are far less profitable for home use. Celery should be grown in like manner, and cut down young and green for boiling.

Some collateral advantages may be fairly anticipated in cases where the back yard is fully enclosed by the canvas.

In the first place, the air coming into the house from the back will be more or less filtered from the grimy irritant particles with which London atmosphere is loaded, besides obtaining the oxygen given off by the growing plants, and the ozone which recent investigations have shown to be produced where aromatic plants—such as the kitchen herbs —are growing. Lavender, which is very hardy, and spreads spontaneously, might be grown for this purpose.

Back doors might be left open for ventilation, without danger of intrusion or of slamming by gusts of wind. The air thus admitted would be tempered both in summer and winter. By wetting the canvas, which may easily be done by means of a small garden engine, or hand syringe, the exceptionally hot summer days that are so severely felt in London might be moderated to a considerable extent. The air under the canvas being cooler than that in front would enter from below, while the warmer air would be pushed upwards and outwards to the front.

Although such conservatories may be erected, as already stated, by artisans or other tenants of small houses, I do not advocate dependence on this; but, on the contrary, regard them as more properly constituting landlord's fixtures, and recommend their erection by owners of small house property in London, and other large towns. A workman who will pay a trifle extra for such a garden, is likely to be a better and more permanent tenant than one who is content with the slovenly squalor of ordinary back premises.

I base this opinion on some experience of holding small houses in the outskirts of Birmingham (Talbot-street, Winson-green). These have small gardens, while most of those around have none. They are held by weekly tenure, and, during 18 years, I have not lost a week's rent from voids, for the men who would otherwise shift their dwelling when they change workshops, prefer to remain and walk some distance rather than lose their little garden crops; and when obliged to leave, have always found me another tenant, a friend who has paid them a small premium for what is left in the garden, or for the privilege of getting a house with such a garden.

A small garden is one of the best rivals to the fascinations of the tap-room, and the strongest argument in favour of my canvas conservatories; and that which I reserve as the last, is that they are likely to become the poor man's drawing-room, where he may spend his summer evenings, smoke his pipe, contemplate his growing plants, and show them in rivalry to his friends, rather than slink away from an unattractive home to seek the sensual excitements that ruin so many of our industrious fellow countrymen.

As above stated, I have not been able practically to test the filtering capabilities of the canvas, owing to my residence out of town, but since the above was written, *i.e.*, on last Wednesday even-

ing, I visited the Houses of Parliament, where, as I had been told, the ventilation arrangements include some devices for filtering the air by cotton wool or otherwise.

I was much interested on finding that the long experience and many trials of Dr. Percy and his assistant engineer, Mr. Prim, have resulted in the selection of the identical material which I have chosen, and with which the above described experiments have been made. A wall of such canvas surrounds a lower region of the houses, and all the air that is destined to have the privilege of being breathed by British legislators is passed through this vertical screen, for the purpose of separating from it the sooty impurities that constitute the special abomination of our metropolitan atmosphere, and that of our great manufacturing towns. The quantity of sooty matter thus arrested is shown by the fact that it is found necessary to take the screens down once a week and wash them, the wash water coming away in a semi-inky condition.

I anticipate that the conservatory filters will rapidly clog, and, therefore, require washing. This may easily be done by means of a jet from a hand-syringe directed from within outwards, especially if the slope of the roof is considerable, which is to be recommended. The filtering screen of the Houses of Parliament is made by sewing the canvas edges together, to form a large continuous area, then edging the borders of this with tape, and stretching it bodily on to a stout frame. This method may be found preferable to that what I proposed above, and cheaper than I have estimated, as only very light intermediate cross-pieces would thus be required, merely to prevent bagging, the strong quartering above described being nine feet apart instead of three. This would reduce the cost of timber to about one-half of the above estimate. The perpendicular walls of a conservatory, where such are required, may certainly be made thus, and I think the roof also, if the slope is considerable. Or, if in demand, the material may be made of greater width than the 3 ft.

So far, I have only mentioned back yards; but, besides these, there are many very melancholy front areas, called "gardens," attached to good houses in some of the once suburban, but now internal regions of London, where the houses stand some distance back from the formerly rural highway. These spaces might be cheaply enclosed with canvas, and cultivated as kitchen gardens, orchard houses, flower gardens, or ferneries, thus forming elegant, refreshing, and profitable vestibules between the highway and the house-door, and also serve as luxurious summer drawing-rooms. The only objection I foresee to these bright enclosures will be their tendency to encourage the consumption of tobacco.

DISCUSSION.

A Member asked if Mr. Williams had observed the effect of wind and rain on this material?

Mr. W. P. B. Shepheard said he was interested in a large square in London, and he had hoped to hear something about the cultivation of flowers in such places. Last year, they tried the experiment with several varieties of flower seeds, and they came up and bloomed well in the open ground without any protection whatever. In most London squares, the difficulty was to find any one bold enough to try the experiment at all, and nothing but experience would prove what flowers would succeed and what would not. They were so successful last year that several fine bouquets were gathered in July and August, and sent to some of the gardening magazines, who expressed their astonishment that such good results were possible in the circumstances. If flowers would answer, there would, of course, be more encouragement to try vegetables. One of the practical difficulties which occurred to him, with regard to this plan, was that the screens would be somewhat unsightly, and then again they might shrink from alteration in the temperatures, and getting wet and dry. He would repeat, however, that, for a very small expense in seeds, a very good show of hardy annuals and perennials might be obtained in July and August even in London.

Mr. C. Cooke said a flower-garden had recently been opened in Drury-lane, on the site of an old church-yard, to which children were admitted; and he wished a similar arrangement might be made in some of the squares in crowded neighbourhoods, such as Golden-square, and especially in Lincoln's-inn-fields. There were lots of children playing about in the streets, and he wished the good example set by the Templars might be followed.

Mr. Liggins, as an old member of the Royal Horticultural Society, felt a great interest in this subject. Among his poorer neighbours in the district of Kensington, cottage and window gardening had been encouraged for some years past, prizes having been awarded to those who were most successful, much to their gratification. This was a novel idea, but he felt quite sure that it would enable those who adopted it to obtain the crops which had been described. There were many collateral advantages which it would bestow on the working classes if largely followed by them, especially the one mentioned by Mr. Williams, that those who devoted their spare time to the cultivation of fruit and flowers would not be so open to the attractions of the public-house. When travelling through the United States some years ago, he was much struck with the difference in appearance of the houses in districts where the Maine liquor law was in force, and soon learned to distinguish where it was adopted, by the clean, cheerful look of the workmen's dwellings, the neatness of the gardens, and the presence of trees and flowers which, in other districts, were wanting. He was not a teetotaller himself, and was not advocating such restrictions, but he could not help noticing the contrast; and he felt sure that in all our large towns great progress in civilisation and morals would be effected if such an attraction were offered to the working classes. He believed there was so much intelligence and good sense amongst them, that if they only knew what could be done in this way they would attempt it, and when an Englishman attempted anything, he generally succeeded.

Mr. William Botly said they were much indebted to Mr. Williams for having called attention to this important subject. He quite agreed with the observations of the last speaker, for his own experience in building cottages showed him that the addition of a piece of garden ground had an excellent effect on the social, moral, and religious welfare of the inmates. It kept them from the public-house, and the children who were brought up to hoe and weed their parents' gardens turned out the most industrious labourers on his property. He had known of instances where houses had been built with flat concrete roofs, and covered in with glass, so as to form a conservatory, in which vegetables and salads grow very well, and he believed the cost was little, if any, more than ordinary slating.

The Chairman, in moving a vote of thanks to Mr. Williams, said there could be no doubt that if his sug-

gestion were adopted it would lead to great economy, and have many other attractions for the working classes. During the last few years they had heard a good deal about floriculture in windows, and no doubt it was an excellent proposal, but if they could add to this the growth of vegetables, it would have economical advantages also. The proposal to erect temporary conservatories on the roofs of some of these small houses was an admirable one. He saw no reason why you should not have a peach tree growing against many a tall chimney; you would only want a metal-lined tub filled with good mould, the warmth of the chimney would aid in promoting the growth of the tree, and it could be protected from the smoke and frost by this canvas. One point he should like to know was, whether the fabric would not become rotted by the weather, and perhaps it might be protected by tanning, or some chemical preparation. The effect of the canvas in maintaining an equable temperature was a great consideration, the difference stated by Mr. Williams, of about 5 degrees in winter, in many cases would be just enough to save the life of a plant. Practical gardeners knew the value of placing a covering over a peach tree in early spring to keep off the frosts, and also to protect them from the attacks of birds. It was also a curious fact that even a slip of wood or slate, a few inches wide, put on the top of a wall to which a fruit tree was nailed, acted as a protection from frost. He trusted that Mr. Williams' idea would find favour amongst the working classes, and thought it was a subject the Royal Horticultural Society might well take up and offer prizes for. He hoped in a short time, when that Society had passed through a crisis which was impending, it might emerge in a condition to devote attention to this matter. It already offered prizes for small suburban flower-shows, but had not yet turned its attention to the larger class aimed at by Mr. Williams.

Mr. Botly said he had forgotten to mention that he had a friend, a very excellent gardener, who always loosened his fruit trees from the wall for about three weeks before the time of blooming. The consequence was, they did not get so much heat from the wall, and the bloom was two or three weeks later in forming. After the spring frosts, the trees were again nailed up close, and he never failed in getting an excellent crop, when his neighbours often had none.

Mr. Trewby wished to caution those who read the paper against using what was commonly known as paperhanger's canvas, because it was made of two materials, hemp and jute, and if a piece of it were put into water it would soon be nothing but a lot of strings, the jute being all dissolved. It did very well for paper-hanging, but would be quite unsuitable for this purpose.

The vote of thanks having been passed,

Mr. Williams, in reply, said he had had a piece of this canvas stretched on a frame exposed all the winter, and the only result was to make it rather dirty. He stretched it as tightly as he could in putting it on, but when it got wet it became still more tight, and gave a little again on becoming dry. It bore the weight of the snow which had fallen very well, and two or three spadefuls had been added to try it. He had a note from Mr. Prim, saying that at the Houses of Parliament the screens lasted about two sessions, being washed once a week, but the destruction was due to the wringing. But there was really no occasion for this, for if you syringed the stuff well from the inside, you made it sufficiently clear to allow the air and light to pass through, and it would probably last many years. He had tried the experiment of dipping it in a very weak solution of tar, but this had the effect of matting together the fine filaments, so that it did not act so effectually as a strainer. It acted best when wet, because the fine particles of soot adhered to it, and moist weather was just the time when the greatest quantity of soot fell. It might be easily tried in London squares to aid in the growth of flowers; he found that the cabbage plants which were so protected throve remarkably well, and he had no doubt that if flowers were planted and a screen put over them until they were ready to bloom, it would be a great advantage. The action of a little peat on the top of a wall to protect fruit trees was very simple, and the explanation was afforded by the experiments of Dr. Wells on dew. The frosts, which did the greatest mischief, were due to radiation from the ground on clear nights; and it would be found that if one thermometer were placed in a garden under an umbrella, and another on the open ground near it, the differences of temperature on a clear night would be very considerable; on cloudy nights there was very little difference. Last night there was only a difference of 2°, but a few nights before it was 6°. The period of greatest cold might not probably be more than hour, but it would be sufficient to do a great deal of mischief, and anything which would check the radiation would have the required effect. In the case of loosening the fruit trees from the wall there was, probably, a double action; it prevented the tree being forced on by the warmth of the wall in the daytime, and also avoided the chilling effect at night, a rough wall being a good radiator, and sinking to a low temperature. He did not think there was much danger to be apprehended from wind, because the canvas being so open, the wind would pass freely through it; but he had not seen it subjected to any violent gale.

MISCELLANEOUS.

FIRES IN THE METROPOLIS.

Memorandum by the Chairman (Mr. Edwin Chadwick, C.B.) of the Select Committee of the Society of Arts of Fire Prevention.

I beg leave to draw attention to the fact of the serious increase of serious fires in the metropolis. In 1877 there were 1,533, of which 159 were classed as serious; in 1878 there were 1,659, of which 170 were classed as serious in the official report; and it is stated that up to this time there has been an increase of the number and seriousness of the fires, as compared with the increased number during the same period of last year. The fire at Earl Granville's house appears to be an example, which is especially noteworthy, for the better understanding of the existing conditions of the metropolis, and the improvements available for protection against extraordinary conflagrations, as well as for the extinction of ordinary fires.

The late Mr. Braidwood, the chief organiser of the Fire Brigade, laid it down as an axiom, that life escapes and water appliances, to be effective, must be brought to bear in five minutes. But in the existing conditions, the Fire Brigade force, according to all testimony, is not brought to bear in less than fifteen minutes:—that is to say, in thrice the time requisite for available protection according to Braidwood's axiom.

The Brigade station happens to be at Chandos-street, at much less than the usual distance of brigade stations from Earl Granville's residence, but the horses have to be put to, which takes three minutes, and the engine could not have been called without a telegraph and brought to the spot in less than eight or nine minutes, before water could possibly be brought to bear, in case the water-plug was found and the water ready. But when the engines did arrive the water-plugs were not at once

to be found; and, according to the testimony of close observers, it must have been full half-an-hour before water was brought to bear.

Now, under proper conditions, or under the conditions of actual practice in Manchester and other cities, the policeman on the beat, who first discovered the flames, would have had in his pocket the key of a hydrant within thirty yards, or in some convenient position, containing the hose, which he would have run out and carried up-stairs, and, in about two minutes, he could have brought a powerful jet, equal to that from a manual engine, to bear upon the fire. Meanwhile, policemen from adjacent beats would have been brought to the spot by signal, and they, having keys of all the hydrants, would have brought two, three, or more jets, if needed, to bear within three or four minutes from the police-stations, which are half the distance of the brigade stations, and there would have been brought, had they been needed, additional apparatus, hose, reels, ladders, extincteurs, and life-saving apparatus, in half the usual time.

A committee of the City Corporation paid a visit to Manchester and examined the police fire-extinction arrangements there, which they have recommended in the City. In their report, they state, as to the practice there:—

"The sub-station man is generally at the fire before the arrival of the engines, and, frequently, two hydrant jets are in use before the Brigade men and engines from the greater station arrive. The committee witnessed various experiments, showing the celerity with which water could be obtained directly from the main, without the intervention of engines. The first experiment was made in front of the Town-hall, when, on an alarm being given at the principal station, the Brigade arrived, and had run out about 1,000 yards of hose, and obtained nine jets of water, in about four minutes. The second experiment was made at a sub-station near the informant, when, on an alarm being given, the fireman in charge by himself obtained a jet of water in one and a-half minutes. The hydrant was near the station. Third experiment:—On an alarm being given at the police-station, Fairfield-road, a fireman started with a hose truck, fixed stand-pipe, ran out about 75 yards of hose, and gave a jet of water in about three minutes after call."

Now, with such a service of one jet in two minutes, and nine jets in four minutes, it may be assumed that the fire at Lord Granville's would have been immediately extinguished, or reduced to comparatively inconsiderable proportions. And the Metropolitan Police fire service gives closer results than this. It is stated that the average time for starting an engine from the metropolitan stations is three minutes. In Manchester the men are fined if they are over two minutes; but at the dockyard police-stations the engines are got out in a minute and a-half.

The Corporation committee returned with the recommendation that the system, as in operation in Manchester, should be carried into operation in the City of London, and it is now being proceeded with there, and several hundred hydrants have been erected there, but most lamely and defectively, from want of the unity of the water-works with the fire arrangements, under unity of the service. The City police have no keys of the hydrants; the keys are still retained in the hands of the water company's turncock, who has to be sought for whilst the fire is spreading, and it is complained that when he is found he commonly applies the water as he pleases, most wastefully and inefficiently.

It is admitted by provincial officers, that advances may be made in the metropolis, on their arrangement, in the recommendations of the Fire Brigade Committee, which sat the year before last, were properly carried out.

The result of the application of these principles of a combined police force, with combined water supplies of a public footing, as compared with that of the separate brigade force, and the separate system of disunited water supplies, in Manchester and in other cities, is a general reduction of insurance risks on life and property to one-third of that which obtains in the metropolis, whilst in London the service of the Brigade force, as a rule, only restricts the fire to the house where it breaks out. In Manchester, as a rule, the police service confines the fire to the room where it occurs; two out of every three losses of life that occur from fire, and two out of every three serious fires that occur in the metropolis (exclusive of the dangers of large conflagrations) are demonstrably due to the maintenance of the existing conditions in defiance of better administrative examples. In Manchester, Liverpool, and Glasgow, horse or steam-engine power, such as is the sole resource in London, is only required in about three per cent. of cases. From the report of last year's fire service of the police force at Manchester, it appears that out of 291 fires, steam or horse-engine power was only required in three instances, the fires being speedily extinguished by the police or others from the hydrants under the constant system of water supply, with the small appliances immediately at hand. The report states that the amount of the property destroyed by these 291 fires was only £35,381 out of property of the estimated value of £1,936,138 "at risk;" that is to say, about two per cent. of the property "at risk."

There can be no doubt that a measure for the metropolis, based on the broad lines laid down by the Select Committee on the Fire Brigade Committee, founded on incontrovertibly successful provincial practice, may be expected to give securities of life and property much in advance of the best of that provincial practice; and every advance is needed on account of the increasing conditions of danger from the increasing constructions of large warehouses in the City, and in the rest of the metropolis, containing masses of combustible materials—often of explosive materials. Officers of provincial forces, who have served in the London Fire Brigade, have expressed serious apprehension of the dangers from these constructions; for if once a fire got ahead in these tall and massive buildings during a hurricane wind, there is nothing to prevent such a conflagration as has not been seen in our times. The other day a fire broke out which destroyed some large warehouses in Watling-street. Fortunately, there was little wind at the time. Had there been a strong wind bearing over the tops of other warehouses, in the direction of St. Paul's, the firemen were of opinion that it might not have been possible to have saved the Cathedral.

From time to time statements are made of progress in separate works of prevention, which are most delusive and dangerous, as leading to false notions of progress in effectual prevention. Nor are there yet the means of sustaining pressure, and of diverting the concentration of the whole power of the water service of the metropolis upon a distinct attack, as it will be seen, from the evidence before the Fire Brigade Committee, given from the insurance companies, was urged by them years ago upon the Metropolitan Board of Works as a necessary protection against great damage. It has been estimated that, for the service of the metropolis, from 70,000 to 80,000 hydrants are needed; but it appears, in the last report of the Local Government Board, that only 4,419 have yet been provided, which number, probably, comprises chiefly those fixed in the important conditions stated. In the water examiner's report, it appears that only 711 miles of street mains, out of upwards of 1,600 miles, are in a proper condition of supply to have hydrants affixed to them, whilst 436,000 houses of the metropolis, or more than four-fifths, are without that condition of supply which Commission after Commission has represented as necessary on sanitary grounds, besides others, and to prevent those conditions of stagnation which make good supplies bad, and bad supplies worse.

A large proportion of the obstruction and delay of amendment, at the expense of life and property, has been at the expense of the undertakings of the separate trading companies from the delay occasioned by their indefinite demands. But a number of recent decisions, sanctioned by Parliament, in the cases of purchasers in provincial towns, have settled terms of compensation which have been generally satisfactory and remunerative to the ratepayers, as well as to the shareholders. On the examination of the official auditor's accounts, made by experts, it appears that upwards of a hundred thousand pounds of the expenses of the administration alone of the seven separate establishments, may be saved by unity of management on a public footing. This amount capitalised would, on the scale of expense incurred at Manchester, serve to put the house service pipes of all the houses in a fitting condition to receive the constant supply without any expense to the parishes or to the ratepayers. Besides the economy of the expenses of administration, there are other sources of economy proved to be derivable from unity on a public footing, which would, after compensating the shareholders on the liberal terms mentioned by Parliament, suffice to effect considerable improvements in the sources and qualities of the future supplies.

The Bill on the lines of the Report of the Committee of the Society of Arts, introduced by Colonel Beresford (with the express promise of the support of the Premier), and supported by Captain Ritchie and Sir Charles Russell, met with approval, and it will be found to have been subsequently affirmed in principle by the Select Committee on the Fire Brigade, after hearing the evidence of all parties, the Metropolitan Board of Works, the Water Companies, the City authorities, and the Commissioners of Police. That Bill, however, was effectively resisted and obstructed by the Directorate of the Water Companies, as not providing distinct terms of acceptable compensation for their undertakings, these terms being then left for consideration and settlement by Parliament. But it may now be submitted that Parliament has in effect removed that difficulty by the settlement, in recent cases, of terms which will no doubt be found acceptable to the shareholders of the undertaking in the metropolis, as they have been to the shareholders of the like undertakings in provincial cities.

The Select Committee on the Fire Brigade of the metropolis heard the witnesses of the Metropolitan Board of Works on their scheme of a separate Fire Brigade force, and a duplicate system of water supply, and set them aside. In their report the Committee state:—"That, whilst the general result of such a concentration of management as they have indicated would be to secure an effective means of extinguishing fires, and thereby diminish the losses of the metropolis, the several changes above mentioned in the system of water supply would be capable of being carried out with much less difficulty and expense if unity of control and consolidation of public interests were allowed to supersede the separate action of the various water companies."

They came to the following resolutions on the general question:—

"That the statutory arrangements for the extinction of fires in the metropolis, whereby the Fire Brigade is administered by the Metropolitan Board of Works, two separate police forces exist side by side, and the water supply is sectionally furnished by eight independent companies, are not such to furnish adequate protection to life and property, and contrasting unfavourably with provincial systems, where the Fire Brigade, water supply, and police are under a single authority; and that the consolidation of management, so far as is practicable, is urgently required.

"That the Fire Brigade should be transferred from the Metropolitan Board to the Commissioner of Police for the metropolis so, however, to constitute a distinct branch, to be placed under the immediate command of a separate Assistant Commissioner, and to be authorised to act within the City of London as well as the metropolis.

"That the police-stations and the fixed points should be used as fire brigade stations, or as the places where small engines or other appliances should be deposited, and that all police-constables, both of the metropolis and the City, should be auxiliary to the Fire Brigade, but that, as now, each force should be empowered to act only within its own jurisdiction, except on a special requisite.

"That hydrants should, without delay, be affixed to mains and service-pipes wherever there is a constant supply, and should follow the extension of such a supply.

"That the water systems now belonging to the various companies should be consolidated in the hands of a public authority, which, in dealing with the questions of constant supply, pressure, and pipeage, should be bound to have regard, not only to the convenience of consumers, but also the requirements for the extinction of fire.

"That effect should be given by the Legislature to these recommendations.

"17th July, 1877."

These resolutions were, in effect, an affirmation of the reports and resolutions of the Select Committee of the Society in 1874.

E. Chadwick,
Chairman of the Committee
of the Society of Arts.

PAPER-MAKING MATERIALS.

In addition to the utilisation of the Blue Moor grass (*Molinea cœrulea*) for the manufacture of paper, referred to in an extract from the *Times* in the *Journal* for January 31st, many other plants common in India and the British colonies might also be mentioned, which, for the most part, have been experimented upon, and the results proved satisfactory, so far as the actual manufacture is concerned. In considering the adaptability of many of the colonial grasses for paper-making, a contemporary, *The Colonies*, recently showed that the great obstacle to the more general application of these new substances is the greater cost as compared with any of the paper-producing materials now in general use. It is suggested that in all probability many of the coarse grasses and other plants, that are now pests and hindrances to agricultural progress in South Africa, Australia, New Zealand, or other colonies, might be turned to good account for paper-making, such, for instance, as the Ruapo of New Zealand (*Typha augustifolia*), a kind of bulrush or reed mace, having a wide distribution, and alike common in wet places in this country. Both in New Zealand and in Australia there are numerous plants of the grass, gedge, or rush kind that would, no doubt if properly tested, be found valuable.

Referring to South Africa as another country from whence fibrous grasses might be obtained, *The Colonies* says:—"In the great Karroo district, thousands of square miles are covered by the characteristic *twaa* grass, the *sour veldt*, and the *sweet veldt*, the importance of which as fodder may possibly be found equalled by their value as a paper material; still more likely to prove valuable in this respect is the *Stipa capensis*, a member of the family to which esparto belongs." It has been truly said that paper can be made out of almost anything, which is, to a certain extent, illustrated by the following list of materials used for paper-making, exhibited at the Amsterdam Exhibition in 1877:—

Arundo phragmites (reed).
Secale cereale (rye).
Hordeum vulgare (barley).
Avena sativa (oat).
Triticum vulgare (wheat).
Scirpus lacustris (bulrush).
Molinea cærulea (blue moor grass).
Humulus lupulus (hop).
Asparagus officinalis (asparagus).
Brassica campestris (cabbage).
Sarothamnius scoparius (broom).
Bambusa officinalis.
Zea mays (Indian corn).
Iris pseudacorus (yellow flag).
Musa sapientum (banana).
Triticum repens (couch grass).
Calamogrostis arenaria.
Urtica dioca (nettle).
Phalaris canariensis (canary grass).
Saccharum officinarum (sugar cane).
Chamærops humilis (European fan palm).

Woods.

Alnus glutinosa (alder).
Æsculus hippocastanum (horse chesnut).
Salix alba (white willow).
Betula alba (white birch).
Tilia europea (common lime).
Pinus sylvestris (Scotch fir).
Populus alba (white poplar).
Populus canadensis.

The question, however, is not what will actually make paper, but what will prove remunerative in a commercial point of view. Perhaps, after all, one of the most interesting of modern paper materials is that procured from the *Yucca brevifolia*, which grows abundantly in the Mojave desert, between the 34th and 35th parallels of latitude, and between the stations of Niojave and Ravena. It grows to a height of from 10 to 20 feet, and the trunk attains a diameter of from 18 to 30 inches. It is described as being composed of short and closely woven fibres, forming a natural textile, very elastic, and growing in layers, one over the other. These yuccas vary much in habit; some of the trees are perfectly straight, unbranched, with a cluster of long narrow leaves at the summit; others again are very much branched, the branches forming irregular and fantastic curves. The leaves, like the stems, are extremely fibrous. The trees are generally known in the country as the cactus. The growth and manipulation of the fibre into paper stock has been described somewhat as follows in the *Journal of Applied Science.* Although they are in great numbers, these so-called cactus trees, do not grow near one another, like forest trees; a space of from 7 to 8 and even 15 feet divides them. The soil is a fine, warm sand, resembling that on a sea shore, and, for a depth of two feet, is very dry, but on digging deeper, water is found. The Southern Pacific Railway traverses this hot and arid region from north to south, and as the plants lie mostly in the country to the east and west, it would be necessary to construct a branch line in case the material becomes an article of commerce, so as to penetrate into the interior of the country. The railway has stations in this desert which are solely for supplying the locomotives with water. A pump, with a windmill as motor, performs this work. The wind in this part of California is very strong and hot. To the southward of the desert, but still on the railway line from Los Angelos, and at 60 miles from that city, is an oasis, and in its centre the station of Ravena, near the Solidad Pass. Here a small paper mill has been built, for working the "cactus" into pulp. The mill has the very best position for this purpose, as it is only about a hundred yards from the station, and two miles further on the desert begins again with a different vegetation, which extends as far as Los Angelos. The yuccas are cut in the desert and brought to the station of Lancaster and loaded on waggons at a cost of two dollars per cord. From Lancaster to Ravena, the distance is thirty miles, and the railroad charges one dollar per cord for the freight. The lands surrounding the railway are divided into sections, and belong to the Government and the Company. The Government collects an annual tax of 25 per cent. per acre, and at the end of three years, by paying one dollar per acre, the ownership may be acquired. The price of the plant delivered at the station is calculated at four dollars per cord. The plant being a strong (resisting) and clean textile, is an excellent material for the manufacture of book and wrapping papers, but the elasticity of the fibre is so great, that particular care must be taken in the boiling. The following is the method employed in the Solidad mill, which is not provided with proper machinery for this kind of work. The yuccas are put into heaps and burned so as to strip them of the bark; this operation is performed in the desert. They are then placed on waggons and carried to the mills, where two men are set to scrape off the burned part, but as the flame has penetrated and blackened the fibre, this cannot be fully attained. The trees are sawn into strips three inches thick, and placed on a decorticator, then three wooden vats are filled, a solution of lime is added, in no fixed proportion, however, and the exhaust of the steam-engine performs the boiling for twenty-four hours. The fibres are taken out of the vats, and two rag engines, each of a capacity of 650 lbs., are filled for the washing, which is done in two or three hours. The result is not a half-stuff which can be immediately transformed into paper, the boiling having had no effect on the fibres; the washing is not completed, and the stuff is greyish and hard to the touch. This half-stuff is spread out in the sun, and with a humidity of twenty-five per cent. is put on the wagons; it is neither pressed nor covered, and is thus brought to the mills at Lict, near Santa Clara. This journey costs six and a quarter dollars per ton. The stuff is here boiled again in a rotary boiler, with caustic soda, then washed and beaten, and finally made into wrapping paper upon a cylinder machine 48 inches wide. The average price of labour is two and a half dollars per day; the freight of the chemicals from San Francisco to Ravena is 14 dollars per ton; and wood costs at the mill of Santa Clara five dollars per cord; and Californian coal six dollars per ton.

The daily consumption of paper in California is estimated at from 15 to 20 tons. A mill at Ravena capable of turning out five tons, could hardly fail of being a complete success, but it would be necessary to have the pulp and the paper manufactured at the same place, and not, as at present, one half at Ravena and the other at Santa Clara, places 400 miles from each other.

The foregoing remarks will have proved the suitability of these *yuccas* for paper-making, and the energy shown by the Americans in adapting it.

CORRESPONDENCE.

INDIAN PLANTS ADAPTED FOR COMMERCIAL PURPOSES.

In the discussion which took place after Mr. Jackson's interesting paper on the above subject on Friday, March 7th, some slight inaccuracies occur in the report of my remarks, which I beg space to correct.

The Conservator (not Commissioner) of Forests in British Burma, who is kindly collecting young bamboo stems for me, and floating them down to Rangoon for crushing, to come to our works here for extended ex-

periments, is Dr. Rerthold Bibbenthrop, and to this gentleman I am indebted for much very valuable information as to the habit, cropping, and cultivation of bamboo under irrigation.

One thousand young seasons shoots will weigh from six to eight tons (not pounds), which, losing from 60 to 70 per cent. in drying, and allowing amply for waste, will yield, when converted into stock, sufficient to make one ton paper. These young stems will cost about 15 rupees, say 30s. per 1,000 delivered by rafts at Rangoon.

My two informants from Demerara tell me they have cut down entire clumps of bamboo during successive seasons without apparently deteriorating the growth, and, one states that even burning the clumps down to the ground has not prevented successive growth, adding that he had seen bamboos seeding on his estate and remaining in healthy growth afterwards, but then it must be noted Demerara is a moist climate and soil, suited to the habit of growth of the bamboo.

In a few succeeding remarks, I intended to show that in treating the old and matured bamboo stems I had not succeeded well, inasmuch as they had become wood, and very hard siliceous, or silicified wood, too—and that similarly to other woods they could only be reduced into a pulp by boiling under high pressure with very costly doses of caustic soda—but that when subsequently experimenting on the young shoots in the vegetable or growing stage, with the sap freely circulating, and before silicate and other compounds had become deposited and indurated, I found that, with the gentler boiling and reduced chemicals, I could treat the stems as readily as esparto grass, indeed, just like cooking a ripe cabbage or asparagus in its succulent stage, reducing them into long and strong fibre.

The question, in fact, of making paper—and good paper, too—from bamboo, is settled. The other question to be determined (by the botanists) remains, viz., whether the bamboo can be continuously cropped every season, to allow the young shoots to be utilised; and, speaking for myself, I have not a vestige of a doubt that, if this operation is judiciously conducted, success will result, and thus a valuable commercial product be added to the exports of India, while assisting our English paper trade, which sadly needs an extended supply of suitable raw material.

Thos. Routledge.

Clanheugh, 17th March, 1879.

In the course of the discussion following the paper on "Indian Plants Adapted for Commercial Purposes," by Mr. J. R. Jackson, Mr. T. Christy is reported to have said that he found great difficulty in inducing medical men at a certain hospital to try chaulmoogra oil. This is so very different from our own experience, that we think the members of the Society of Arts will be sufficiently interested in it to warrant us in begging that you will kindly insert this letter in your next issue. In the course of a very general introduction of chaulmoogra oil, in which we have interested ourselves now for more than a year, the difficulty spoken of has never been experienced by us. We have placed the oil in, perhaps, every large hospital in London, and in some of these it is now being regularly used; we have received orders for it from various parts of Scotland and Ireland, and from scores of medical men and chemists in England, who now regard it as part of the ordinary *materia medica*. We have also sent the oil to Belgium, Germany, France, North America, the Cape, and Australia, and altogether have destributed some four hundred pounds, not a small quantity in the time, if it be considered that the dose is small, that most of the cases in which it is used are chronic, and that no systematic report on the cases treated has yet appeared. We were pleased to see the unqualified commendation of chaulmoogra given by Sir Joseph Fayrer and Surgeon-Major Balfour. We hold numerous letters from physicians and patients recounting the salutary effect of the oil, but have preferred to file these, pending the more formal and authorised reports. Our experience will show you and others interested in the discussion above referred to, that medical men are not averse to the use of new remedies which come well recommended, and which are brought properly before them. With regard to the supply of it, our sources are so abundant that we do not share the doubt expressed by Surgeon-Major Balfour as to the possibility of obtaining a large quantity of chaulmoogra oil. We hold a good stock of the pure oil at the present time, and it is not likely that our arrangements will be at all strained, unless a very much larger demand than our experience leads us to anticipate should suddenly arise. In conclusion, we would refer you to a preliminary paper on the chemistry of chaulmoogra oil by our partner, Mr. John Moss, which appeared in the *Chemist and Druggist*, December, 1878, and to a pamphlet by Mr. R. C. Lepage, late of Calcutta, in which you will find all that has hitherto appeared on chaulmoogra oil carefully compiled. We may say that the appearance of this pamphlet was the first important step in our systematic introduction of the oil to medical practice outside of Hindostan.

Corbyn, Stacy, and Co.

300, High Holborn, London,
March 18th, 1879.

THE COMPENSATION OF CLOCKS, WATCHES, AND CHRONOMETERS.

In reading his paper on "The Compensation of Clocks, Watches, and Chronometers," Mr. E. Rigg, through shortness of time, did not enter so deeply into the subject as he has done in the printed report in the *Journal*. This naturally has left some of his printed assertions unanswered; I therefore trust that you will allow me space for a short reply. Mr. Rigg says "another balance of Kullberg's design, known as the flat rim balance, has given excellent results," but is, he believes, now rarely or never used. This is a very erroneous and to me injurious statement; the balance has never been very extensively used, even by myself, owing to its cost, but it is used by myself now as much as formerly; and although my balance-makers have promised to make that balance for me alone, yet I have had chronometers of other makers to repair with the same kind of balance, and further, a chronometer with such a balance stood second in order of merit at the competitive trial at the Royal Observatory in 1876, and was purchased by the Admiralty in consequence in 1877. Another chronometer, with my auxiliary compensation, also stood second on the list, and was also purchased by the Admiralty. Neither of these chronometers had my name attached to the balance for obvious trade reasons. The auxiliary balance of my construction is used extensively by myself as well as by other makers, and is becoming more general every year, owing to its simplicity and consequent cheapness.

V. Kullberg.

105, Liverpool-road, London, N.

GEOGRAPHY IN RELATION TO COMMERCE.

Kindly permit me, as having been present at the interesting discussion on Mr. Bradshaw's paper, read on Tuesday night, before the African Section, to call attention to one aspect of the question which was not then touched upon. What was then brought forward, was a demand for a large capital to open up Africa to trade. We had various schemes proposed for the formation of lines of railway, and differences of opinion were expressed as to the right part of the continent to attack, and as to whether it was advisable to plunge at once into railroad-making,

or to be content at first with utilising and improving existing means of transport. But, while there is this uncertainty, even amongst those who are practically acquainted with Africa, how is the question to be appreciated by the public, from whose pockets the funds are to come, and who possess so little sound knowledge of African geography? Central Africa, which lies so much nearer European shores than do America, China, or Australia, is practically more distant and unreal, and holds a smaller place in the minds of the ordinary British public than any of those three countries. One of the best remedies for this apathy in regard to the splendid continent which is lying, comparatively speaking, at our doors, is that geographical knowledge should be made widely accessible and intelligible, which is not at present the case. Not only African geography, but geography generally, is apt to meet with unfair treatment; the importance of accurate geographical conceptions in keeping alive and giving definition to an otherwise vague interest in foreign countries, is not sufficiently recognised. Geography is worthy to be ranked as a first-class study by the side of history and other sciences; instead of which we find it generally treated as a secondary matter, sufficiently developed in school-boys' books, small manuals, and gazetteers. It is to the necessity and practical utility of rescuing geography from this position, and of giving it a higher place in popular interest, that I wish to draw attention. The Royal Geographical Society does excellent service in this direction, but it stands almost alone. In order that the public may accord to geography its right place in education and amongst the sciences, its claims must be recognised by the Universities. If this were done, it would be a great gain to the country at large. It is a reproach to a commercial and imperial power like ours that we are so far behind other nations in this respect. In Germany there are Professors of Geography at the Universities of Berlin, Halle, Marburg, Strasburg, Bonn, Göttingen, and Breslau; in Switzerland at Geneva, Zurich, and Neuchatel; in France at Paris, Bordeaux, Caen, Lyons, Clermont, and Nancy; while at Marseilles a professorship of history and commercial geography is attached to the *Faculté des Sciences*. This good example is not followed by us. We have no such provision for geographical teaching at either Oxford or Cambridge. It is to be hoped that the appeal recently made to the Universities Commissions by the Royal Geographical Society will lead to this omission being supplied. A step in the right direction has already been made by the Manchester Chamber of Commerce in the proposed establishment of a school of commercial geography; an example which might well be followed at Liverpool. If geographical information, by these and other means, can be made at once more generally accessible, more intelligible, and more interesting, the public will be more on the *qui vive* with regard to opportunities for action abroad, and more ready to contribute towards commercial enterprises such as that which Mr. Bradshaw is advocating.

George G. Butler.

EDUCATIONAL CONFERENCES.

For a quarter of a century the Council of the Society of Arts convened an annual conference of delegates from the mechanics' institutions and similar educational associations affiliated to the Society. The last of these conferences was held in 1875, when they were discontinued, and the Domestic Economy Congress substituted. I believe it was considered that the Educational Conferences had ceased to elicit any suggestions or proposals likely to have practical efficacy. Without expressing an opinion in regard to the reasons for discontinuing these conferences, I can readily believe that, taking into account the difficulty of finding the best men on the institution committees to attend on the day fixed, and also the limited character of the constituency, that the discussions were not so useful as friends of education would desire for meetings only held annually. But knowing the importance of giving the fullest consideration to a problem, the solution of which is daily acquiring greater interest, the development of a progressive scheme of education for the industrial classes commencing from the period of leaving the day schools, it seemed to me then, and my observations in the interim have strengthened the opinion, that instead of discontinuing these meetings, as if either their object had been accomplished or its attainment was hopeless, the right course would have been to continue them, but to impart to them a broader representative character. Those who have watched, as I have, for many years, the intermittent hesitating progress of advanced education among the operative classes, must hold with me the conviction that this is a subject demanding grave and active consideration. The Society of Arts took the lead in encouraging technical study by its examinations, certificates, and prizes. But the results will inevitably be small until means are found to induce the young operative to enter on an apprenticeship in such study concurrently with that of his trade. To effect this some machinery, not yet in existence, is needed, that will facilitate study in night classes upon a consecutive plan, so that the several divisions of the requisite knowledge may be taken in their proper order. Such questions as whether this should be done by the Education Department of the Government, or by the localities, or by the co-operation of the two, would be comparatively easy of settlement, if the main outlines of a plan of progressive instruction with technical aims were agreed on.

I offer this as a plea for the revival of the annual Educational Conference on an extended basis, and with a clearly defined purpose.

W. H. F. Traice.

27, Arcade-chambers, Manchester.

NOTES ON BOOKS.

England and Africa. A Lecture delivered in Great Yarmouth, February, 1878, by Sir T. Fowell Buxton, Bart. London: Stanford, 1879.

A lecture, delivered by Sir T. Fowell Buxton to the Literary and Scientific Society of Great Yarmouth about twelve months since, has recently been published by Mr. Stanford. The lecture comprises a sketch of the general condition of Africa at the present time, and of the recent progress of geographical discovery in its interior regions. In summarising the work that has already been done in reference to the suppression of the slave trade, Sir Fowell says:—"The results of exploration show that we have in Africa a great continent, rich in products of immense value in the European markets, with immense tracts of fertile soil, and a climate ready to produce almost anything that can grow—Indian corn, and every kind of grain—and teeming with peoples ready to receive English manufactures and commerce. . . . We have this great continent before us. It is difficult to think of it without believing that the time has come when an effort should be made to see if legitimate trade and commerce could not be introduced into the country of Africa. This is not an idea felt by England alone, but it is felt on the Continent also. . . . The influences that must be depended on as of first importance for this work are those of religious missions, commerce, and good government. Some controversy has risen in reference to these influences. Some hold that one, and some another, is to be regarded of supreme importance. It appears to me that of all controversies this is the most idle and useless.

What is manifest is that in the work before us—the civilisation of a continent—each must have its share, and that none can be neglected . . . There are, no doubt, many circumstances existing in Africa resembling those which have existed in other places, and which have led to the introduction of English rule. We have English settlements around the lakes, and between the coast and the lakes. We may expect these to increase in number as trade increases, and it is not unlikely that, in one way or another, English government will be asked for. Should the demand come, it will be difficult to resist it. It may even be that Englishmen will go there, and their conduct be such that we should feel it necessary to follow them in order to assert our authority over them and keep them in order, and this may lead to English authority being extended over the country. It is a mere question whether such a result is to be desired or not. It may be good or it may be evil to extend our Government, but it must be a bad thing to drift into it without fully making up our minds and without preparation. It is my belief that our proper line of policy is to take advantage of any organised Government, such as we have in one part of Africa or another, and so direct and guide it as to increase that authority and improve the Government."

GENERAL NOTES.

American Tea.—Over fifty thousand tea plants, says the *Scientific American*, havo been distributed lately in the Middle and Southern States, by the Bureau of Agriculture. In three or four years these plants will be large enough to permit a full picking of the leaves. Experiments have been made with tea leaves grown in the grounds of the department and in the South, after Japan methods, the product being pronounced an excellent Oolong by dealers and experts. The only present obstacle to the profitable cultivation of tea in this country on a large scale is the amount of hand labour required in curing the leaves. The Commissioner is confident that American ingenuity can produce machinery by means of which the preparation of the leaves may be effected better and cheaper than is possible even with "Chinese cheap labour." There is no good reason why any family having a garden plat in the southern and middle portions of the United States, should not produce with little trouble all the tea needed for home consumption, without elaborate machinery.

Dates as Food.—"G. P. B." writes to the *Pall Mall Gazette*:—In these days of trade depression and high cost of provisions of all kinds, I wish that the attention of the poorer classes could be directed to the eligibility of dates as an article of food at once cheap and nutritious. Dates are extensively consumed by the lower orders in Egypt, as also by the Arabs in the Persian Gulf and on the Shattu-'l-'Arab beyond al-Basrah, with whom dates and bread form their principal diet. Those in better circumstances cook them in different ways, such as frying them with a little *ghee*, or made into an omelette with eggs; and I can myself vouch for the savouriness of such dishes. Formerly, the only dates imported into the London market were those from Egypt, called Tafilat, which were and are still sold by grocers at from 8d. to 10d. per pound. But the Tafilat, albeit a large and fine-looking fruit, have a tough skin, and are far less succulent and nutritious than those now brought from al-Basrah and the Persian Gulf. These latter are disposed of wholesale in boxes or straw sacks, at from 10s. to 14s. per cwt., and are hawked about the street for from 2d. to 4d. per pound. A more general demand for the fruit would probably lower the retail price, and it would be a great boon to the poorer classes if they could be convinced that one pound of dates, costing about three halfpence, contains as much nutriment as half a pound of meat, and much more than the same weight of many of the articles of food for which they pay six or ten times the price.

Institution of Mechanical Engineers.—The Research Committee of the institution have selected for first investigation the three following subjects, and are anxious to obtain information bearing on all or any of them, *e.g.*, records of unpublished experiments, references to authorities on the question, copies of books or papers in which it is treated, &c. The committee would be glad to receive such information in full detail, and at the earliest convenient date; and it will be suitably acknowledged in their report:—Subject A. The hardening, tempering, and annealing of steel. Subject B. The best form of riveted joints to resist strain, in iron or steel, or in combination. Subject C. Friction at high velocities, specially with reference to friction of bearings and pivots, friction of brakes, &c.

African Exploration.—M. Hugo de Koppenfels writes from Eloby, Gorisco Bay, a little to the north of the French Gaboon colony, that he has been exploring the country during several weeks of pouring rain. He ascended the Muni, the Noya, the Balinji, and the Tambuni to the first falls. In the Crystal Mountains he fell in with tribes absolutely unknown up to the present, or who at least had not been seen by whites, with rare exceptions—the Etemo, the Manga, the Otonto, the Toko. These people are scattered in the middle of the Fans or Pahouins and the Osszeba, but speak languages differing from those of the two latter. Their idioms have much resemblance to that of the Shekiani and the Balinji. These people, M. Koppenfels tells us, are very inoffensive; they regarded him as a curious animal, and had a certain fear of him. They tried to render them service, and were much less importunate in their mendicity than the other negroes of that coast. When he asked them to accompany him into the interior, they agreed with a certain enthusiasm, assuring him that the peoples he would meet with were not wicked. They are frightfully poor, and much weaker than the Osszebas. They are obliged to give up planting on account of the ravages of elephants and gorillas, which are very numerous and daring. Not a single night passed, M. de Koppenfels states, that he did not hear these animals ravaging around the villages, which are, for the most part, very large. As soon as the animals are known to be near, the whole village is on foot endeavouring to frighten them away by shouting. In these nocturnal expeditions, in which the explorer took part, he noticed that the headman of the village addressed a speech to the elephants, and that in this speech his own name was pronounced. He was told that the elephants were threatened to be handed over to him, and that if they did not fly at once they would be visited on the morrow and the white man would kill them. If the elephant seizes a plant with its trunk, the people immediately raise a dreadful, plaintive howling, and the principal orator addresses, in a lamentable voice, supplications to the enormous brute.—*Times*.

NOTICES.

MEMBERS' SUBSCRIPTIONS.

The Secretary would feel obliged if those Members who have not already paid their annual subscriptions for the current year would do so at their earliest convenience. Cheques should be made payable to "H. T. Wood, or Order."

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

March 26.—"The Treatment of Iron to Prevent Corrosion." A second communication. By Professor Barff, M.A. F. A. Abel, Esq., C.B., F.R.S., will preside.

April 2.—"Some Causes of the Recent Depression in Trade." By B. Francis Cobb, Esq., Treasurer of the Society.

April 23.—"English Fresh-water Fisheries." By J. Willis-Bund, Esq., Chairman of the Severn Fishery Board. Francis T. Buckland, Esq., M.A.., H.M. Inspector of Salmon Fisheries, will preside.

April 30.—Renewed Discussion on Mr. John Hollway's paper (read February 12) on "A New Process in Metallurgy." Prof. H. E. Roscoe, F.R.S., will preside.

African Section.

Tuesday Evenings, at Eight o'clock.

April 1.—1. "Remarks upon an Old Map of Africa contained in Janson's Atlas, published in Paris in 1612," and exhibited by R. Ward, Esq.; and, 2. "The Submarine Telegraph to South Africa," by J. Sivewright, Esq., Superintendent of Cape of Good Hope Telegraphs." W. H. Preece, Esq., will preside.

April 29.—1. "Light Railways for Opening-up a Trade with Central Africa," by John B. Fell, Esq.; and, 2. "The Advantage of Railway Communication in Africa, as compared with any other Mode of Transport," by J. Conyers Morrell, Esq.

May 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

Chemical Section.

Thursday Evenings, at Eight o'clock.

March 27.—"The Inoxidation of Iron and the Coating of Metals and other Surfaces with Platinum, by the Processes of Mons. Dodé." By L. M. Stoffel, Esq., C.E.

Indian Section.

Friday Evenings, at Eight o'clock.

March 28.—"The Practicability and Advantage of a Ship Canal through the Island of Ramiseran." By Simon McBean, Esq., C.E.

May 2.—"The Wild Silks of India, especially Tussah." By Thomas Wardle, Esq.

Cantor Lectures.

Second Course, by Dr. W. H. Corfield, M.A., on "Dwelling-houses: their Sanitary Construction and Arrangements."

Lecture VI. and Last.—March 24.

Water-closets, Sinks, and Baths.—Arrangements of pipes, traps, &c.

Third Course, by W. H. Preece, Esq., on "Recent Advances in Telegraphy."

Lecture I.—April 21.

Definitions of telegraphy and electricity. Electrical effects. Sources of electricity. Economical distribution of electric currents.

Lecture II.—April 28.

The transference of electricity. Wires. Insulators. Supports. Gutta-percha, india-rubbe. Underground wires and cables.

Lecture III.—May 5.

Simple telegraphy. Visual and aural signals. Telephones. Telegraphic writing.

Lecture IV.—May 12.

Duplex, quadruplex, multiplex, and harmonic telegraphy.

Lecture V.—May 19.

Automatic and fast-speed telegraphy.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS,** John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. W. H. Corfield, "Dwelling Houses: their Sanitary Construction and Arrangements." (Lecture VI.)
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. Professor Geikie, "Geographical Evolution."
British Architects, 9, Conduit-street, W., 8 p.m. Mr. James K. Colling, "Architectural Foliage."
Medical, 11, Chandos-street, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Prof. R. Bentley, "The Life of a Plant."

Tues. ...Metropolitan Scientific Association, 160a, Aldersgate street, E.C., 7 p.m.
Royal Horticultural, South Kensington, S.W., 1 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture XI.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. James N. Douglass, "The Electric Light applied to Lighthouse Illumination."
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Mr. Henry Seebohn, "Some particulars respecting the Native Races of Arctic Siberia," accompanied by an Exhibition of Ethnological Objects collected in that region. 2. Sir Charles Nicholson, "Some Rock Carvings found near Sydney, New South Wales."

Wed.... **SOCIETY OF ARTS,** John-street, Adelphi, W.C., 8 p.m. Prof. Barff, "The Treatment of Iron to Prevent Corrosion."
Geological, Burlington-house, W., 8 p.m. 1. Prof. E. Hull, "The Geological Age of the Rocks forming the Southern Highlands of Ireland, generally known as 'The Dingle Beds' and 'Glen-garriff Grits and Shales.'" 2. Mr. D. Mackintosh, "Results of a Systematic Survey (in 1878) of the Direction and Limits of Dispersion, Modes of Occurrence, and Relation to Drift-deposits of the Erratic Blocks or Boulders of the West of England and East of Wales, including a Revision of many years' previous observations." 3. Mr. A. J. Jukes-Browne, "The Southerly Extension of the Hessle Boulder-clay in Lincolnshire." 4. Mr. John Horne and Mr. B. N. Peach, "The Glaciation of the Shetland Isles."
Royal College of Physicians, Pall-mall East, S.W., 5 p.m. (Croonian Lectures.) Mr. W. H. Stone, "Some Applications of Physics to Medicine." (Lecture III.)
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Dr. Davey, "The Dramatic Literature of Italy."
Society of Telegraph Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. James Sivewright, "South African Telegraphs."

Thur....**SOCIETY OF ARTS,** John-street, Adelphi, W.C. 8 p.m. (Chemical Section.) Mr. F. L. Stoffel, "The Inoxidation of Iron, and the Coating of Metals and other Surfaces with Platinum, by the Processes of Mons. Dode."
Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 7 p.m. Mr. Ebenezer Prout, "The Harmonium."
Royal Institution, Albemarle-street, W., 8 p.m. Prof. Tyndal, "Sound." (Lecture VIII.)
Inventors' Institute, 4, St. Martin's-place, W. C., 8 p.m.
Philosophical Club, Willis's-rooms, St. James's, S.W., 6½ p.m.

Fri......**SOCIETY OF ARTS,** John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. Simon McBean, "The Practicability and Advantage of a Ship Canal Through the Island of Ramiseran."
Royal United Service Institution, Whitehall-yard, 3 p.m. Capt. J. C. R. Colomb, "The Naval and Military Resources of the Colonies."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting; 9 p.m. Sir Henry C. Rawlinson, "The Geography of the Oxus, and the Changes of its Course at different Periods of History."
Quekett Microscopical Club, University College, W.C., 8 p.m. 1. Dr. M. C. Cooke, "The 'Dual-Lichen' Hypothesis." 2. Mr. F. A. Bedwell, "A Successful Method of Examining the Anatomy of *Actinia Mesembryanthemum.*"
Clinical, 53, Berners-street, W., 8½ p.m.
Royal College of Physicians, Pall-mall East, S.W., 5 p.m. (Lumleian Lectures) "The Pathological Relations of the Voice and Speech."

Sat......Royal Institution, Albemarle-street, W., 3 p.m. Mr. F. Seymour Hayden, "Etching." (Lecture II.)

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,375. Vol. XXVII.

FRIDAY, MARCH 28, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1879, early in May next. This medal was struck to reward "distinguished merit in promoting Arts, Manufactures, or Commerce," and has been awarded as follows:—

In 1864, to Sir Rowland Hill, K.C.B., "for his great service to Arts, Manufactures, and Commerce, in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefits of which have, however, not been confined to this country, but have extended over the civilised world."

In 1865, to his Imperial Majesty, Napoleon III., "for distinguished merit in promoting, in many ways, by his personal exertions, the international progress of Arts, Manufactures, and Commerce, the proofs of which are afforded by his judicious patronage of Art, his enlightened commercial policy, and especially by the abolition of passports in favour of British subjects."

In 1866, to Professor Faraday, D.C.L., F.R.S., for "discoveries in electricity, magnetism, and chemistry, which, in their relation to the industries of the world, have so largely promoted Arts, Manufactures, and Commerce."

In 1867, to Mr. (now Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S., "in recognition of their joint labours in establishing the first electric telegraph."

In 1868, to Mr. (now Sir) Joseph Whitworth, F.R.S., LL.D., "for the invention and manufacture of instruments of measurement and uniform standards, by which the production of machinery has been brought to a state of perfection hitherto unapproached, to the great advancement of Arts, Manufactures, and Commerce."

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For.Memb.R.S., Chevalier of the Legion of Honour, &c., "for his numerous valuable researches and writings, which have contributed most importantly to the development of food economy and agriculture, to the advancement of chemical science, and to the benefits derived from that science by Arts, Manufactures, and Commerce."

In 1870, to M. Ferdinand de Lesseps, "for services rendered to Arts, Manufactures, and Commerce, by the realisation of the Suez Canal."

In 1871, to Mr. (now Sir) Henry Cole, C.B., "for his important services in promoting Arts, Manufactures, and Commerce, especially in aiding the establishment and development of International Exhibitions, the development of Science and Art, and the South Kensington Museum."

In 1872, to Mr. Henry Bessemer, "for the eminent services rendered by him to Arts, Manufactures, and Commerce, in developing the manufacture of steel."

In 1873, to M. Michel Eugène Chevreul, For.Memb.R.S., "for his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world."

In 1874, to Dr. W. C. Siemens, D.C.L., F.R.S., "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the Arts; and for his improvement in the manufacture of iron; and generally for the services rendered by him in connection with economisation of fuel in its various applications to the Manufactures and the Arts."

In 1875, to M. Michel Chevalier, "The distinguished French statesman, who, by his writings and persistent exertions, extending over many years, has rendered essential service in promoting Arts, Manufactures, and Commerce."

In 1876, to Sir George B. Airy, K.C.B., F.R.S., the Astronomer Royal, "for eminent services rendered to Commerce by his researches in nautical astronomy, and in magnetism, and by his improvements in the application of the mariner's compass to the navigation of iron ships."

In 1877, to Jean Baptiste Dumas, For.Memb.R.S., member of the Institute of France, "the distinguished chemist, whose researches have exercised a very material influence on the advancement of the Industrial Arts."

In 1878, to Sir Wm. G. Armstrong, C.B., F.R.S., D.C.L., "because of his distinction as an engineer and as a scientific man, and because by the development of the transmission of power—hydraulically—due to his constant efforts, extending over many years, the manufactures of this country have been greatly aided, and mechanical power beneficially substituted for most laborious and injurious manual labour."

The Council invite members of the Society to forward to the Secretary, on or before the 26th of April, the names of such men of high distinction as they may think worthy of this honour.

SIXTEENTH ORDINARY MEETING.

Wednesday, March 26th, 1879; Prof. F. A. Abel, F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Bullock, Thomas A., 11, Old Broad-street, E.C.
De Chaumont, Francis Stephen Bennet François, M.D., Woolston-lawn, Southampton; and the Army Medical School, Netley, Hants.
Giffen, Robert, 44, Pembroke-road, Kensington, W.
Huson, Charles W., 5, York-buildings, Dale-street, Liverpool.
Williams, Frederic Bessant, F.S.S., 2, Ludgate-hill, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Chambre, Alan Edward, Camera-lodge, South Norwood, S.E.
Cheston, Charles, 5, Clarence-terrace, Regent's-park, N.W.
Phillips, Samuel E., 14, Charlton-villas, Church-lane, Old Charlton, S.E.
Roberts, Owen, M.A., Clothworkers'-hall, 41, Mincing-lane, E.C.

The paper read was—

THE TREATMENT OF IRON TO PREVENT CORROSION.

By Professor Barff, M.A.

It is now more than two years ago since I had the honour of introducing to your notice in this room a process for the prevention of corrosion in iron; and it was through the Society of Arts that it was first made known to the public. My paper then met with a very flattering reception, both from this Society and from the public press. An article appeared in the *Times*, which, written with great ability, gave to it a claim to public consideration, and with one or two trifling exceptions, it was well spoken of in all directions. The exceptions to the general desire manifested to receive well a process which, if practicable, was highly desirable, as being likely to increase largely the use of iron, and to enable it to replace, for certain uses, other metals which were injurious to health, were not founded on reasons of sufficient force to cause me to notice and answer them, and some of them, which could only result from the inner consciousness of those who made them, without an atom of proof, have been fully answered by the work which has been subsequently carried out on a larger scale at my laboratory at Kensington. I was blamed by some for bringing out my invention too soon; but I think that you will see that, by following the course I did, I was enabled to give specimens to those who have very thoroughly tested for a long time the goodness of the process; so that I, to-night, stand before you armed with a large amount of experience, and with testimony from others on whose word and judgment reliance can be placed. In answer to some remarks made by the Chairman on the night when I read my first paper, Admiral Selwyn stated that the black oxide of iron had stood the action of sea water for ages, and he therefore advised us to look to nature for a proof of its enduring properties, on the shores of New Zealand, where quantities of it had existed unchanged since the creation of the world. No one, who has a right knowledge of its properties, could doubt its power to resist atmospheric influences, and even the action of sea water; but the doubt that did exist in the minds of many was whether it could be produced artificially on iron, so as to keep its place, and enable the iron beneath it to resist their action as well; or, rather, I should say, whether its adherence to the iron was so complete and perfect as to protect it from them. Pieces of iron will be shown you which were exhibited on that occasion, which have been exposed ever since, and you will be able to judge for yourselves whether the protection afforded by the black oxide is complete and perfect, or not. I feel that I ought, before proceeding further, to notice briefly one or two of the exceptions to which I have alluded in the reception which my first paper met with. One was that the process was not original; that I had no right to claim, as my discovery, what had been known to chemists for years. I will quote from my paper, and then you will see whether I deserve this charge or not. "In every school where chemistry is taught, in the most elementary lecture on hydrogen, the pupils are told that, if they pass steam over red-hot iron filings, contained in an iron tube, they will be able to collect and burn the hydrogen gas at the opposite end of the tube to where the steam enters. For a long time it was thought that the particles of black oxide formed by this decomposition of the steam were pulverulent, and could not be made to cohere into a solid mass." It is manifest that I could not claim as my invention what I stated was already known. Another exception was that the process might be of use for small articles—pots, pans, &c. —but that it could not be applied to large articles, and, even if it could, it would so materially weaken the iron that dependence could not be placed on its strength; in fact, if I remember rightly, a solemn warning was given to persons not to trust to it. Now, that the process is only applicable to pots and pans, &c., the articles before you will disprove. At the beginning of my experiments, I did not wish to incur a great outlay, and, therefore, the chambers, or muffles, used were not large. A year and a half ago, I had a chamber built of fire brick, and that has been in use ever since. In it articles six feet long have been treated; and if the chamber were 12 feet long, or 20, articles of such lengths could be treated as well as those which you see before you. As to the action on the strength of the iron, bars treated have been tested for breaking and tensile strain, and the result is that the strength of the iron is not affected, and the persons who tested them assert that they would not hesitate to use the process because of any injurious effect which it has on the strength of iron. I need not do more this evening than briefly remind you that my process consists in oxidising the surface of iron by means of superheated steam. In my former paper a description of the rusting of iron will be found; it is enough for my present purpose to state that the black oxide of iron is unaltered by any of the ordinary influences which produce red rust, and which therefore cause the destruction of iron.

The points which I have to bring before your notice this evening are those which two years' experience has enabled me to discover in the method of working the process; and these are very important, because formerly there was a want of certainty in performing it which gave very unequal results. During the last eighteen months I have been able to give constant attention to it, which I was not able, from my engagements, to do before, and now I can assert that it can be conducted with ease and with perfect certainty. In the specification of my patent, the method of performing the necessary operations is given, but considerable practical experience is required, which it is impossible to describe in writing. In the earlier experiments performed at my laboratory at Kilburn, it was often found that the coating of black oxide scaled off wrought-iron articles. This is never the case now. This scaling resulted from an insufficient and irregular supply of steam to the muffle during the operation, whereby air was not excluded, but was often forced in from the want of a sufficient pressure of water on the superheating pipes. Air must be completely excluded from the oxidising chamber, because, if the oxidation of the iron depend, during any part of the process, on the oxygen in the air, such oxide formed will not adhere to the iron properly. This I have proved by submitting iron to oxidation by dry air, and in every case wrought-iron has, when so treated, lost

its coating, which has flaked off in scales; and in the case of cast-iron, the oxide on exposure eomes off in a very short time, and therefore does not provide perfect protection to the iron. If, however, the air forced into the chamber be moist, the same result occurs with wrought-iron, but with cast-iron the coating formed does adhere for a time, and the length of its adherence is proportionate to the quantity of moisture present in the air. If the air be forced into the ordinary chamber from a vessel in whieh it is in contact with water, and if the temperature of the room in which this vessel is be high, as in such a case it must be, the quantity of moisture converted into steam, when at the temperature of the iron to be oxidised, will be great, in fact. enough to oxidise the iron, for very little steam is required to oxidise a great weight of iron, but then the oxygen of the air will take part in the action, and wherever the iron is oxidised by the oxygen of the air its adherence will not be complete, and though by being mingled with the other oxide it may have a certain amount of stability, yet in a short time it will come off. I exhibit two specimens in illustration of this, one of cast the other of wrought iron, both of which have been exposed in the open for some time; the piece of cast iron did not rust for some time after it was exposed, but the wrought iron flaked and rusted at once. It appears, therefore, to be absolutely necessary to secure a good result, that air must be completely excluded from the oxidising chamber.

For a long time I experienced considerable trouble from the appearance of small spots of rust on articles otherwise well coated, which were immersed in water. The spots of rust appeared to increase in size, but on examinatien it was found after washing off the rust, which could be easily removed, that it originated from small openings in the coating of black oxide. It required a magnifying glass to see these openings; the rust did not spread by more of the iron surface rusting, but because the rust formed in these minute cracks was carried out by the water in which the articles were, and was therefore diffused about. Such rusting has no effect on the strength of the iron, and after a few cleanings it eeases altogether. However, I felt that it was very necessary to prevent it, and that led me to seek carefully for its cause. When iron is heated it expands, when cooled it contracts. If iron be heated in an oxidising chamber it expands, its pores, so to speak, open. If a jet of superheated steam be admitted at a temperature lower than that of the iron in the chamber, the iron will contract, and then will decompose the steam, of course it must be at a sufficiently high temperature to do so. Now, the iron will gradually get hotter, and will expand again, and the first thin coating of black oxide will be in part cracked, and as the oxide goes on forming it will in part cover and fill up these cracks, but I think—in fact I am sure—that it does not do so perfectly, and hence some of them remain, the iron at the bottom of them being coated with but a very thin film of oxide. Reasoning in this way, I came to the conclusion that no contraction must be allowed to take place in the iron after the oxidising action had commenced, and to secure this, the ordinary chamber is always kept at a mueh lower temperature than the superheater; and now it is never allowed rise above five or six hundred deg. Fahr. before the superheated steam is admitted, and the steam is never allowed to pass in at a temperature less than one thousand deg. This for a long time has been our invariable plan of work, and in no case whatever have we experienced any failure as long as the apparatus was sound. Many have tried experiments, independently of me, but in all cases I have heard complaints that they have not succeeded, and I feel sure that the want of success has been due to one of the causes I have mentioned, or to another which I described in my former paper, viz., the presence of moist steam.

When asked by my lamented friend, your late able Secretary, to read another paper on my iron process, I willingly consented to do so, because it would give me the best method of making public and explaining the difficulties I had met with and overcome, but which were still troubling others who take a real interest in the process. It has always been my opinion that the best way of forming the black oxide on iron is to conduct the process by means of superheated steam alone, because the steam, being the source of heat to the iron, raises its temperature to that at which it can decompose steam, so that oxidation commences immediately the iron is hot enough. When the iron is heated in the chamber, before the steam is allowed to act upon it, there is always danger of air getting into the chamber and forming a film of oxide before the steam gets to work, and this is a thing to be avoided. I have only been able to experiment with superheated steam alone on a small scale, and the large chamber has flues up its side which would conduct off the heat if it were attempted to raise its temperature by superheated steam alone. I may be here misunderstood. The flues at the sides of the chamber would cause cold air to circulate round it, and the heat from the superheated steam would thus be conveyed away. The experiment I did perform was with an iron muffle, similar to that which was used in the early experiments. This was surrounded with fire-clay, to act as a non-conductor of heat. Steam, at 1,500 deg. Fahr., was injected into it for a short time, and then the articles to be treated were put inside it, and the steam was again let in. In a short time the muffle and its contents became red hot, and, after a few hours, were found to be well coated with black oxide. I could not work this process on a larger scale, for I have already, through the assistance of a friend, expended a large sum of money in experiments, which have resulted in my being able to state that my process is now commercially perfect, and is waiting the enterprise of gentlemen in the iron trade to take it up and use it. When I last had the pleasure of addressing you I spoke with diffidence, and I could not give definite answers to those who questioned me; now I can speak with confidence, and though I cannot perhaps reply to all questions to your entire satisfaction, yet I can assert that there is no reason why this process should not be largely adopted. Adopted it will be, for it is a success, and has been proved to be so by the testimony which I have the pleasure of submitting to you. But, before submitting these testimonials, allow me to say a few words about the properties which this artificially formed black oxide

possesses, as to which I could not testify in my first paper. It gives great hardness to the surface of iron, when the coating is sufficiently thick; by this I mean when it is even less than one-sixteenth of an inch. An ordinary flat rasp will not remove it without great labour; it resists emery powder, as I stated in my first paper; but now I have proved that it will for a long time resist a rasp, and will remove pieces of steel from it. This has been witnessed by many, among these by M. St. Yves, Engineer in Chief of the Ponts et Chausées, Paris, who was sent over to report on the process, and Professor Frankland. Substances which adhere to iron, zinc, and enamel will not adhere to it. Saucepans in which arrowroot and other sticky substances are cooked can be cleaned with the greatest ease, after they have been oxidised, a simple wipe removing all dirt. I exhibit a saucepan which has been in use at my house for two years, and a wrought iron stew-pan which has done about six months' service. I have a whole set of stew-pans at home, and my cook prefers them much to any others. Dr. Mills, of Glasgow, testifies to the same property. You see before you a urinal which was in constant use at my laboratory for months, and was then sent to be used here two months ago. There are no deposits on it. I had water evaporated in an oxidised pan for six weeks—common tap water; the water never boiled, but was slowly evaporated. The deposit found was removed with a duster; it did not stick to the iron. This is a matter of great importance to boilers, and for pipes through which water is to be conveyed.

Now, articles coated can be submitted to a high temperature, even a red heat, without the coating being injured or disturbed. One of the appended testimonials speaks to this.

I have written to most of the gentlemen to whom specimens were sent two years ago, after my first paper, and most of them have kindly replied. Their letters I have published, even those which show that at present my process does not meet their requirements. Where it has not answered, I have added in a note my own remarks for what they are worth. At present I fear that iron wire cannot be treated successfully—the wire can be treated and will not rust, but it cannot be bent to a sharp curve without the coating coming off. I show a specimen to prove that the wire, when not bent, does not rust, and that articles made of wire can be made non-rustable provided they be not stretched beyond a certain point. Rivetted iron plates can be most successfully treated; the process tightens the rivets and assists the caulking; the plates before you show this. I have not solved the question of rivetting plates after treatment, but I am sanguine that I shall be able to do so. Weights were treated for the Government, and submitted by Mr. Chaney to tests, and the process is now recommended by that Department for the standard weights throughout the country. I also exhibit two specimens, one of oxidised, the other of common iron, on which gold leaf has been put in the ordinary way, with oil gold size, and I think they illustrate well that even where it is desired to paint or gild iron to be placed in exposed situations, it is very desirable to have it first treated by my process; both the specimens have been out of doors for two months, exposed to rain and snow; for some days they were completely buried in snow.

I regret to say, gentlemen, that I cannot speak very definitely as to the cost of the process. I do not wish to delude any one by a statement that it can be done for so much per ton. It is simply impossible to do this, as you will see. Hollow goods—such as saucepans, &c.—will take up a much larger space per ton than a ton of 56 lb. weights, and this shows how fallacious any general statement on this head must be. My experiments have not been conducted with special regard to economy, but to efficiency, and, having settled this point, economy must now be inquired into. This is rather the work of the manufacturer than mine; but this much I can say for your guidance, that, even with my means, the cost for light articles does not exceed that of galvanising. But I do think that, if the treatment gives a permanent protection to the iron, that articles treated by it should command a higher price than those which have been treated by a less enduring process. My experience tells me that different kinds of cast iron behave differently under treatment. Some kinds require longer exposure to the action of the superheated steam than others. Why this is I cannot as yet find out. Of this class is the iron in which the carbon is in more perfect chemical combination as a carbide. This iron is whiter than the other kinds. There are before you specimens which have resisted the rusting action of air in the presence of water. The two statues exhibited and other articles are of a different kind of iron; they required a shorter exposure, and have stood equally well. I have not yet met with any sample of cast iron which could not be properly treated. Wrought iron requires a somewhat different treatment; a lower temperature, about 900 deg. Fahr., suits it best, and steel also. It is not well to expose articles very different in bulk at the same time, all that are put into the muffle should be pretty nearly equal in bulk. I mean that very heavy articles, such as a 56 lb. weight, should not be treated with these gutter spouts. Cast and wrought iron should not be treated together; but all these are matters which a little experience will regulate perfectly. Sometimes the sand from the mould adheres to cast iron; this is often the case inside pipes; it is of no moment, for the sand itself gets so firmly fixed on the coating of black oxide, that it assists in protecting the iron. I have proved this by severe experiments. In clearing off the rust from iron before it is submitted to the action of superheated steam, the usual method is employed, it is immersed in dilute oil of vitriol, and after washing is put into some bran water; this last operation is to remove any basic sulphate of iron from the surface. If this basic sulphate is not completely taken away when the iron is heated, it is reduced, and red oxide of iron is left on the surface, which has the colour of the red oxide used for paints, and you will see some articles so coloured before you; this red oxide does not prevent the formation of the black oxide beneath it, and does not interfere with its stability, it is therefore of no importance, except to the appearance of the articles.

Having now trespassed so long on your patience and time, I have only to say that I hope you will ask me any question you please, in order that I may, if I can, resolve any doubt which you may feel as to my process. I have also the pleasure of

stating, that Mr. John Spencer, of West Bromwich, will shortly be prepared to treat articles which may be entrusted to him.

Reports as to Professor Barff's Process for the Prevention of Corrosion of Iron Surfaces.

From Messrs. John Warner and Sons, Hydraulic and Sanitary Engineers.

The Crescent Foundry,
Cripplegate, London,
March 6th, 1879.

The closet pan which you covered for us, and which was sent to us in November, 1878, we have exposed to the atmosphere ever since—four months ago. It has been placed so as to be exposed to snow, frost, rain, and smoke, and we do not see the slightest appearance of rust or detriment. We have purposely subjected this piece to this particular test in order that we may decide as to the adaptation of the process to some other articles. We are so satisfied that it will be what is wanted for this particular purpose which we have in view, that we have fully decided on the matter, and shall take the opportunity of calling upon you in a few days, when we will fully discuss the arrangements which may be made as to the future.

From The Silber Light Company, Limited.

49, Whitecross-street,
March 11th, 1879.

We have subjected the lamp stands (nine in number) to an ordinary test, viz.: exposure in a damp place, and on examining them a few days ago could trace no apparent alteration in their appearance, and certainly there was not the slightest sign of rust. These were received by us from you on October 22nd, 1878.

From Messrs. Chubb and Sons, Patent Safe and Lock Makers.

129, Queen Victoria-street, London, E.C.,
March 6th, 1879.

1. 10-inch key box. This was placed at the bottom of a wrought-iron tank for 13 days (the goods were received on September 24, 1878). On being taken out, particles of rust were found inside—the lid not having been on box—but, as they were flaky, I presume they were detached from sides of tank. They were wiped off easily, and the blackened surface appeared intact. Sides, both inside and out, were not affected in the least. I then put a small quantity of water in the box, and let it remain until evaporated. Fine rust appeared, which was again easily wiped off; but, on repetition up to last Monday, the magnetic oxide seems to have given, as small spots of rust adhere firmly. Still, I consider the result satisfactory.

2. A set of bolt work. This was replaced in safe, and the appearance of same has been much approved. Up to the present, no signs of rust have shown, nor has any one of the bolts shown signs of scoring. Perhaps their "look" is not quite in keeping with the general appearance of a safe, although, being black, they form a good contrast against the light stone colour we use inside.

3. One key. This, after being worn on a bunch for four weeks, was put in water, and rusted badly in parts. I have had it on my chain ever since, and the result has been that the oxide is worn off the edges of bow, steps, and moulding on shank. Its appearance, too, is not smooth, small portions of the surface having scaled off in the operation of coating. Perhaps a longer exposure would give better results. However, on the whole, I think the process is a decided success, especially for pieces which are not in constant wear or friction, unless such friction be regular and even.

From Messrs. J. Arthur Young and Co., Engineers and Contractors,

102, Corporation-street, Manchester,
December 4th, 1878.

We have had a piece of corrugated iron which had undergone your process, outside exposed to the weather, and we are glad to say that the part which had the coating stood the test thoroughly, but the other parts from which we had removed the coating had all gone with rust. It was outside for six weeks. We shall be glad to know your price per cwt. or per ton for applying your process to sheet iron.

From Messrs. John Hardman and Co., Art Metal Workers.

Birmingham,
10th March.

One of the pieces of iron treated with Professor Barff's process was made up into a bell-pull, and has been consequently much handled and exposed to all kinds of weather, and it stands well and without any apparent change.

From the City of Dublin Steam Packet Company.

9, Regent-street, Liverpool,
Engine Department,
March 14th, 1879.

The two pieces of plate we received in August, 1877, were, on the 30th of that month, put into the steam-room of one of the steamer *Leitrim's* boilers (surface condensing), the larger piece as part of the linings we were then putting on the shell plates of the boiler to preserve them, the smaller being hung to one of the stays. These, with an ordinary plate of lining adjacent to the larger, were detached and taken out of the boiler to-day, and portion of the surface of each scraped free of scum scale. The larger plate has lost its oxide coating in several irregular places, which can easily be scratched by a knife, but as yet without any appreciable wasting, while where the coating is still perfect the knife cannot penetrate; the smaller is in good condition, almost, if not quite, as perfect as when put in.

The ordinary plate has been joggled, or set, at each end to fit over joints of the shell, when it has been treated for this purpose, and the "mill shell" thrown off thereby; it is somewhat wasted, but where that shell has not been disturbed, it is in as good condition as the others. No doubt the coating is of the same description as that of the process.*

We have not yet had an opportunity of fixing any of the screwed stays in a boiler, but on the 14th October last, one was placed in the water gutter of a building in the company's repairing yard, where iron would waste very rapidly. It has now only two or three discoloured places and spots on it, apparently from rust; but, as it turns out, the foreman by mistake placed two pieces of iron in the gutter under it, and I am strongly of opinion that these stains have been imparted to them, as they are entirely confined to the surface, and elsewhere the stays are as clear and of the same texture as when put up.†

John Nicholson, Superintending Engineer.

From Professor E. J. Mills.

Anderson's College, Glasgow,
March 8th, 1879.

I have submitted two of the articles you sent me last October, as illustrations of your process, to fair systematic testing. The little pot has been in constant use in my kitchen, and shows nowhere any sign of rust; nor will grease or starch adhere to it. The kettle has been in frequent use; it shows no rust except in two or three spots, which are evidently flaws in the casting (a common iron kettle is rusted afresh every day by our

* These plates were treated before the system I have described was employed, and then scaling sometimes happened.—F. S. B.

† These screws were treated in the latter method.—F. S. B.

Loch Katrine water). I am so convinced of the perfect success of the process that I have ordered the roof-railings and ventilators of my new laboratory to be protected by it.

From Mr. W. Arthur.

Ringsend Glass Works Co.,
Dublin, March 8th, 1879.

We have pleasure in reporting our experience with the iron treated by your process. The thick lumps of cast-iron have given great satisfaction, as they are never exposed to a temperature above dull red heat in the dark, and moist air does not cause rust. The moulds have been also improved, but they show a roughness and slight shrivelling on the skin, owing, we venture to think, to not being exposed sufficiently long to the process. The short cylinders of malleable iron we may say the same of, but they are exposed to a very severe ordeal, being often heated to a temperature of about 1,800° Fahr., and frequently air cooled at 70° Fahr. during the day, which of course causes the skin to peel off; this could also be remedied if you could make the oxidised skin much thicker.

From Mr. B. Donkin, Jun.

Shortlands, Kent,
March 9th, 1879.

With regard to the 24 bars (wrought iron) coated by your process, they have hardly been exposed long enough—three to four months—for my report to be of much value. They are used as supports of rose trees, and on examining them yesterday appear to be quite free from rust, except at top, where the iron has been indented by hammering them into the ground.

From Mr. J. Coneybeare, Engineer.

Belmont-place, East Greenwich,
March 11th, 1879.

The four long bolts treated by your patent process in October last have been exposed in my shops, without having any oil or grease of any kind, ever since, and there is not the slightest sign of any rust at present; although all other iron had to be kept oil or greased, during, especially, the late frosty weather.

From T. Maxwell Witham, Esq.

5, Gray's-inn-square, London,
March 10th, 1879.

The portions of roller skates treated by your process have given great satisfaction. Before being so treated, it occupied one man to keep them free from rust, as the skates are at Ostend and the rink there close to the sea; but since they have been treated they are quite free from rust. The skate fittings you treated for me personally have also given great satisfaction, but these have not been submitted to the action of the sea air like those at Ostend.

From Messrs. John Dewrance, and Co., Engineers.

176, Great Dover-street Borough,
March 18th, 1879.

We have tested your patent coating for iron surfaces in the most severe way, and we found it impossible to rust the iron where the coating was intact. We consider it is a very valuable invention, and capable of most varied application.

The City of Carlisle Gas Works (Mr. J. Hepworth, Engineer).

March 13th, 1879.

The pieces of pipe treated were placed in a humid atmosphere, and I find that they present no change in appearance whatever. Note—This was 12 months' trial.

The Admiralty Committee on Boilers.

15th March, 1879.

Experiments still proceeding with pieces of iron plate treated by the process.

Messrs. Wilkinson, Engineers.

Fountain Works, Bradford,
March 15th, 1879.

Springs treated did not corrode, but the temper was taken away from them.

The Spongy Iron Water Purifying Co. (Bischof's Patent).

505, Oxford-street, London,
March 6th, 1879.

The pieces of iron treated by your process were placed in a filter for the Admiralty, but at present we are not informed of the result.

Patent Ferrule Company.

Birmingham,
March 5th, 1879.

The goods were sent to Captain Gill (Cunard line), and we have not yet had his report.

W. Avery and Co., Pin Manufacturers.

Birmingham,
March 5th, 1879.

The pins do not get rusty or corroded, but they lose their temper.

DISCUSSION.

Sir Antonio Brady said he had had one of the specimens shown by Prof. Barff on the first occasion exposed ever since, and it was as perfect as any now produced. It occurred to him that if the iron plates of our ironclad ships could be protected, it would confer an immense blessing on the nation.

Dr. Russell said he looked at this process rather as a chemist than as a practical man, and, from a scientific point of view, it was, no doubt, one of great importance. Last July twelvemonths, Prof. Barff gave him a specimen of cast-iron which had been coated by the first process, and he took particular interest in it, because he pointed out that it was imperfect, and evidently it was, because there were two or three little specks of rust upon it. He had kept it exposed ever since in a conservatory, where it had been every day alternately wet and dry, and had been kept at a tolerably high temperature, and on that day examining the specimen, it was evident that that part which had been protected had remained perfectly intact. Moreover, the oxidation had gone on very little indeed on those parts which were exposed, so that practically this piece of cast-iron was really in very much the same condition as it was last July twelvemonths.

Prof. Graham said that one or two years ago Professor Barff gave him one or two small articles, and since then had supplied him with several others for the purpose of exhibiting at one of his lectures. Having heard in the north of England one or two unfavourable remarks with reference to the success of the process, he had tested these articles in a way similar to that just described—not in a greenhouse, but in a laboratory, where he had hydrochloric acid and other oxidising vapours. He found that some stood remarkably well, though one or two showed the usual signs of rust. Of this Professor Barff had given the explanation. The fact was that those particular articles supplied to him were prepared at a time when he had hardly discovered the right way to do it. This was really the cause of one or two of the failures in the north of England. They have not had the steam at a higher temperature than the article. The tempera-

ture of the steam must be at least 400° or 500° higher than the article submitted to it, and that would make the process a perfect success. He considered it a most successful one, and a great boon to this country. A question had been put with reference to large plates, and to it, he believed, at the present moment a definite answer could not be given, because the element of cost was one he was not able to speak confidently about. Professor Barff had not told him how he proposed to produce superheated steam at 800° or 1,000° in large quantities, so that very large chambers could be heated up by it, and large articles might be coated. He should very much like to hear this.

Dr. Poore said Dr. Barff, some months ago, gave him a door-handle, which he had had lying about in the house. While everything else made of iron or steel was rusting, or was rapidly decaying, this remained perfectly sound. No householder in London would, if he could help it, have any of the fittings in a room made of iron, for it was well known that iron rotted quicker than almost anything else. Curtain hooks, locks, and things of that kind, if not constantly attended to, very soon became useless, but this method offered a solution of all these difficulties. He was one of those who believed that the great future of gas was for heating rather than lighting purposes, and he has gas-stoves put in his own house, but he found that one of the difficulties of ordinary gas fires, as made with asbestos, was that the iron burner very quickly got coated with oxide, and the gas burnt as in an ordinary burner, smoking instead of burning properly. Professor Barff had treated one of the burners for him, but with only partial success. The corrosion had not been so extensive as before, but there was a good deal of it, and also of rusting; but he should state that it was done under very disadvantageous circumstances, the burner being already made up, and Prof. Barff explained to him that the steam could not properly act on all the surface of the iron, and he was going to try another, direct from the manufactory, which he had no doubt would be successful.

Admiral Selwyn had great pleasure in pointing out the importance of the whole subject, and also referred to the unreasonableness of those who, when an inventor put before them something new, expected it to be as perfect in every respect as if it sprang, like Minerva, fully armed from the brain of Jove. They could not expect perfection at first; but, even if they could attain to a very small degree of perfection in this matter, the result would be of great importance, particularly in those iron structures which were rapidly replacing every other form of construction, giving an enormous degree of stability, such as could not be looked for at present. For instance, when the Britannia-bridge was erected, it was perfectly well known that its life was limited, and that those parts into which you could not get to paint after construction must necessarily wear out sooner or later. This was a most important matter, because, not being able to enter the bridge, we could not see exactly what was going on, so that an accident might happen at any moment, and after a certain number of years a large expense would have to be incurred, which might have been avoided had a small portion of these results been obtainable by the peroxidation of the plates before being put together. It was possible that the treatment of rivets and rivet-holes might not be quite so satisfactory; but that was a detail for the manufacturer rather than the inventor. With reference, again, to the girders, which were largely used in underground railways in London, no one could stay long at one of the stations without remarking the fearful extent to which corrosion was going on, so that, sooner or later, a large portion must be taken out at one time, with a serious interruption to the railway traffic. All this might, by such an invention as this, have been avoided. In all inventions there were three phases; first, when the thing put forward was said to be no good; secondly, when it was said not to be new; and thirdly, when it proved to be both new and good, and then everybody tried to rob the inventor. With regard to the subject of boilers, it was of the greatest importance that boilers should not decay as rapidly as they did. A great ironclad went to sea with her boilers capable of supporting a certain pressure, but she had not been to sea two years before her boilers were obliged to be worked at a lower pressure per square inch, and their inefficiency diminished in an enormous ratio. Anything which would give greater durability and efficiency to boilers was of the utmost importance. This was being done by an engineer, who did not see, as Professor Barff had done, the chemical part of the question, but he had succeeded without knowing it. Mr. Perkins had made boilers which were submitted to very high temperature and pressure. Inside they were entirely made up of tubes, about 3 in. in diameter, and were called "tubulous boilers." One of these, after it had been at work 13 years, was cut open by the Boiler Committee, and the internal surface of the tubes was found to be coated with what he should call imperfect peroxide. It was not bright and uniform in its surface as these articles were, but it had had the effect of completely stopping all corrosion, and the boiler after 15 years working was as good as when put up. There was one point in connection with boilers which, he hoped, Professor Barff would investigate. He had tried the action of sulphates and hot sulphuric acid, but chlorine was a much more dangerous enemy of iron than even sulphuric acid. It had a peculiar action known as "pitting," and, unfortunately, they could not get rid of the chlorine in salt water, even by distilling. With regard to the artistic work, he saw a specimen on the table which would almost deceive an amateur into thinking it was a patina of that ancient workmanship so much valued. The lines of the casting seemed to be perfect, not showing the slightest filling up of the channels or anything of that kind, and this showed that the making of iron, one of the strongest metals, into the subject of the highest artistic design, was well worthy of the attention of that Society and of manufacturers. There were some people who objected to everything of this kind which provided greater durability, saying it was bad for trade, but he had no sympathy with such notions. Whatever added to the durability of what we used, added to the wealth of the nation which was able to develop such an invention. There was one point to which he was really commissioned to pay attention, and which he hoped would be borne in mind by the whole of the British public. It was this—that we ought to give more protection to capitalists—he did not say to inventors—to induce them to assist in things of this kind. It was the uncertainty of the law connected with the protection of inventions which prevented capital raising up in this country trades and manufactures which would replace the stable articles of which we had lost the monopoly, and would enable us to pay for our food, as we had very little prospect of doing at the present moment. If the desire was to see the industry of this country raised to its old level, it would not be accomplished by any repressive means, still less by insisting on human nature changing, but by recognising the necessity of protecting all that kind of development which increased the wealth of the nation. As soon as this efficient protection for the labour of the inventor was obtained, he had no doubt that Prof. Barff would get rid of all difficulties in having his invention taken up. Manufacturers saw that there necessarily must be some tentative work, and they did not desire to engage in it, to see the whole profits of their labour taken away from them because everybody could do the same. Whether they regarded this process as a question of protecting water-pipes underground, or pipes in mines, or as a question of art or of utility, it was equally important that such an in-

vention should be thoroughly understood and carefully investigated.

Mr. Liggins said he came specially to hear if this invention was likely to be applicable to shipping, a subject in which he had been interested all his life. As iron and steel ships were superseding wooden ones, he felt anxious to know if this process would prevent the corrosion of ships by sea water. Up to the present time this had not been accomplished. Paints wore off, rubbed off, and rotted off in a way which was anything but satisfactory to shipowners; and if this process were applicable, it would no doubt be a great success. The specimens presented seemed to indicate that the process must be applied to large surfaces; but even apart from that, it was well-known that in the minor parts of ships iron was largely protected by the galvanic process. But there were objections to it, because it was alleged to diminish the strength of the iron, and in many parts great strength was required. He alluded especially to some of the bolts, which were so essential to the safety of the rigging, and to cables and anchors, upon which the safety of the whole ship depended. He remembered when the galvanising process first came up. An anchor so treated was supplied to the royal yacht *Victoria and Albert*, and some doubts were expressed whether it would be safe, owing to the heat of the process to which it was subjected; but it had since become universal on board yachts, and he had ridden out some very heavy storms in large yachts where the anchors and cables were both galvanised. The comfort of a galvanised cable on the deck of a beautifully-kept yacht was very great, for nothing made a greater mess of a clean deck than a rusty cable. There were many bolts in wooden ships which were generally made of iron, rather than copper, on account of the extra strength, such as the chain plate bolt, but these were a constant source of expense, because they corroded very rapidly, so that every two years or so, the ship had to be docked and the bolts replaced. He had sometimes seen them taken out in such a state that he could break them off with his fingers. He should like to know if this process would be applicable to cables, or whether the coating would be liable to be removed by the violent concussion with the iron hawse pipes when the cable was rapidly run out. He thought this one of the most valuable inventions ever brought before the Society.

Colonel Prendergast hoped the profession to which he belonged would be allowed to take its share in what he considered one of the greatest inventions of the time. It appeared that up to the present very large articles had not been put to the test which smaller ones had, but the army dealt in small articles as well as large ones, and it would be a great thing if this process could be applied to the thousand and one small details, the care of which were of immense trouble to the service. There was one unfortunate matter connected with the profession, that when peace came they were all for burnishing and varnish, and making things look pretty. At this moment, however, we were engaged in more than one war, and if they could enlist the aid of the Chairman, possibly an attempt might be made to introduce this process for some of the articles now being sent out to the seat of war. Nothing but a practical test was of much use in such matter, but a few months wear in Zululand would give every test necessary for the purpose. At the close of the Crimean war a quantity of galvanised bits were tried, but they were a complete failure. They would not stand the test of strength, and above all, they were ugly. As far as he could see, from some of the articles exhibited, a considerable amount of beauty might be attained if the metal were properly prepared. It would be an immense boon to the soldier if he had a scabbard which would not rust, for half his day was taken up in cleaning his accoutrements. He would also ask, in reference to artistic purposes, whether it would be possible to prevent any particular portion of the metal receiving the oxide if so desired.

Mr. Bromhead asked if the process were applicable to steel articles, such as axes, hatchets, and things of that kind?

The Chairman said Mr. Barff had stated that he objected to the use of air, but he was no doubt aware that there was, at any rate, one gentleman, Mr. Bower, of St. Neot's, who was carrying out a process of treatment with air—he could not say whether dry or moist air—and he claimed a certain measure of success. He exposed the articles, both of wrought and cast iron, in a current of heated air, 1,500° or 1,600° Fahr., for a period of six or seven hours. It had also come to his notice recently, that, in France, a Captain Bourdon had tried the action of hot air, and it was stated in the *Revue d'Artillerie* that he had successfully applied the process to coat gun barrels with magnetic oxide. As he described the process, he had a large chamber, in which he put 400 or 500 barrels, and raised the temperature to 550° or 570° Fahr., exposing the barrels to a moderate current of air for about five hours. He said they came out coated with a loose film of red oxide, which was removed with a greasy rag, and then he found a coating of black oxide beneath, which he believed would form a considerable protective; and he had been commissioned by the Government to treat a large number of barrels in this way. He should like to know whether, in Mr. Barff's opinion, the results thus obtained were likely to at all compare in durability with those which he had described and shown. He had inspected a large number of Mr. Barff's specimens, which had been submitted to all kinds of severe usage, and could testify to the remarkable durability of the coating he produced by means of superheated steam.

Prof. Barff, in reply, said there were on the table several specimens of rivetted plates, and both the rivets and caulking were improved by the operation. It was feared at first that in fitted boilers the rivets would be started and the caulking interfered with, but this proved not to be the case. Girders and rivetted structures could be treated, provided the chamber was large enough, but there seemed to be some doubt about the size of the chamber. All he could say was, that Dr. Siemens had told him that a chamber of any size that could be heated could be supplied with superheated steam to properly oxidise articles of any size. The late Secretary, Mr. Foster, only a few nights before his death, was present at a conversation between Dr. Siemens and Mr. Nasmyth, when the former expressed his opinion, unhesitatingly, that the process could be applied to chambers of any ordinary size as perfectly and easily as to the small chamber in which his experiments had been carried on. Who would have imagined a few years ago that steam hammers would be employed, and that the enormous guns we now saw would be made? All these things grew as the necessity for them arose, and there was no *prima facie* difficulty in the way of articles of any size being treated. He could not say much about armour-plates at present; he was working at it, but as he had spent some thousands of pounds on this invention, with the help of a friend, he thought it was now time for the manufacturers to come forward and do something. Over £6,000 had been spent on these experiments already, and he could hardly be expected to spend another £6,000 in building a series of large chambers for armour-plates. How were these plates rolled now? Simply by enterprise. No one dreamed twenty or thirty years ago that such plates could be made; but the necessity arose and they were produced. Here was the necessity, and the thing could be done. He had some plates which had been rivetted after being coated; the plates being first drilled, and the rivets and plates being coated. They had been exposed for some time, and were perfectly intact, except that the rivets had rusted

where the coating had been removed by the rivetting. But how long would it take for a rivet to rust entirely through its length? So that even if nothing more than that could be done, it would be a great protection, and there would be very little difficulty in a man going round, if necessary, with a pot of black paint, and touching up the heads of the rivets. The smooth surface produced, which nothing stuck to, argued very much in favour of its resisting the attachment of those nasty things which cling to a ship and so much impeded its progress. He did not like to speak of what he was trying, nor would he do more now than say that his attention was being turned to this matter, and that before long he hoped to be able to coat the heads of rivets *in situ*, the plates being done first. He could not answer Dr. Graham's question about the way in which the superheated steam would be supplied to the chamber, because, though he had ideas on the subject, he had not formed a definite plan, and it was more an engineering than a chemical question; he was now being advised by skilful engineers, and he hoped that this desideratum would be attained. The main point in Admiral Selwyn's remarks was as to the action of chlorine. This could only be answered by experiment; you could not theorise about it. When he read his first paper, he spoke of certain experiments he had performed with acids, and said that the iron resisted their action, and, on repeating the experiments, he found his statements were not absolutely correct; so with regard to chlorine, if he made an assertion now, he might say something which he might afterwards have to modify. It was down on his notes that this experiment, amongst others, should have an early trial, for he knew the difficulties occasioned by chlorine, and he felt as anxious as anybody to remove them if possible. With regard to cables, as he had said, wire would not rust, but if bent beyond a certain angle the coating scaled off, so that the cable would have to be coated entire. Whether the friction would wear it off he could not say; it must be tried. If anyone tried to file off the oxide from any of these articles it would take them many hours, but a few knocks with a hammer would chip it. There were many parts of a ship which could be treated with advantage. There was a screw on the table which had been in use in a yacht for a long time, and bolts could be done perfectly. In answer to Colonel Prendergast, he might say that if you coated a portion of the metal with pieces of fire-clay mixed with borax, you would prevent the formation of the oxide. Whether you could do it in sharp lines he could not say. With regard to the gas-stove sent him by Dr. Poore, it was very rusty, and it was impossible to clean off the rust from the inside of the pipe. He was going to try a new burner, which he had no doubt would turn out better. He should add that, even where there were defects in the coating, the scale never came off by the rust burrowing beneath it, and this was a most important matter. If a large girder was being put into position, it would scarcely be possible to avoid blows here and there, which would remove portions of the scale; but as the rust would not spread, it would not affect the real strength of the structure; and, in fact, if the area exposed were not large, the red oxide which formed on the iron itself acted as a protection against further oxidation, as he had proved in several instances. This was not the case with copper rusting, which would eat right through the iron. He had no wish to speak of other processes, because it might be supposed that feelings of competition would come in, but there was really no competition btween himself and Mr. Bower. That gentleman had seen his process, and then devised a scheme of his own, and wrote and suggested that they should join. He replied that he should be quite willing to do so, provided his process would do what he said, and he asked him to send him the most perfect specimen he could of his process. That was a year ago last summer. He sent him a specimen at Margate, and in about six weeks' time it was rusted nearly all over. Other specimens had been shown him, which had not been so rusted, and he believed Mr. Wood had a specimen.

Mr. H. T. Wood said he had a specimen in his garden, which had been placed under a water-tap, and it had kept very well on the whole, but it was spotted in part with red rust.

Professor Barff said some of his early failures arose from air being in the chamber. In an article on this process, it was stated that he forced air from a gas-holder, but if that were so, and the air came from a furnace house, it would be saturated with moisture, so that there would be a considerable quantity of water held in suspension, which water would be decomposed, and the iron would be oxidised. In order that it should be done by air alone, the air must be thoroughly dried, and if this were not done, he was advised that it would be an infringement of his own patent. Whatever adhesion there was of black oxide to the surface, his experience taught him was due to moisture, and that in dry air you did not get perfect adhesion at all. With regard to the French experiments, he had seen a statement that, in one case, Capt. Burdon used air, and in another steam; but there was no statement as to whether or not the air was dried, and that made all the difference. He had not seen the report to which the Chairman referred, but he had seen an article in a newspaper, stating that the gun-barrels were tested by dilute hydrochloric acid, and at once put it down as humbug, because no black oxide would withstand the action of that acid. It would take the coating off any of the articles on the table, and make them quite rusty. When one read a statement of that sort one lost confidence in the whole report; but he should be glad if the Chairman could procure some of the gun-barrels, and test them. Steel could be treated equally as well as iron, but it lost its temper. Whether it could be retempered he did not yet know, but one or two gentlemen had undertaken to try it. Two pieces of Whitworth steel were now undergoing the process, and any gentleman who would like to see the result could do so by attending at his laboratory in Wright's-lane, Kensington, the following morning at twelve o'clock.

The Chairman said Mr. Barff had thoroughly established the success of the process he brought forward some two years ago. Like many other inventors, he had had many difficulties to contend against, and they could not but admire the truly British pluck with which he had met all discouragement. They had before them abundant proof that the process was applicable to a great variety of purposes, and it would be very foolish not to apply it to them because it had not yet been proved to be applicable to something else. There was no doubt in his mind that if the applications of it with success were extended by practical men, the occasions in which they hoped to see it applied would increase, and that though there might be difficulties perhaps at first, success would eventually follow. Some persons had gone so far as to intimate that because Mr. Barff applied magnetic oxide to iron surfaces he claimed the idea that this oxide was a protective of his own. He would never dream of doing anything of the sort, but great credit was due to a man who, having observed that this oxide was a perfect protective, not only conceived the idea of applying it, but brought to a practical issue a means for coating with ease and comparative simplicity small articles of iron. Their thanks were due to Mr. Barff, not only for his very interesting paper, but especially for the great perseverance with which he had combatted the difficulties which he had met with in carrying out the process, and he begged therefore to propose a hearty vote of thanks to him.

The vote of thanks was carried unanimously, and the meeting adjourned.

MISCELLANEOUS.

OBSERVATIONS ON INJURIOUS INSECTS.

The causes and effects of insect depredations to our field crops and garden produce have received much elucidation of late years from the labours of a few indefatigable entomologists, notably the late Mr. Andrew Murray, and foremost among them, at the present time, Miss E. Ormerod, who has done so much in many ways to advance a knowledge of economic entomolgy. The importance of the subject Miss Ormerod has taken in hand cannot be controverted, whether or not her labours and those of her co-workers will bring about what they desire, namely, a diminution in the number or extent of insect pests which attack our food plants. This is a question that time alone will answer. It is certain, nevertheless, that a good work is being done in encouraging habits of observation, and the report issued each year shows a marked improvement over that of the preceding year, both in the extent and value of the observations recorded.

During the past season, it is said, the most remarkable feature of economic insect observation has been the unusual absence in most places of any great amount of damage, from even the most common of our injurious insects, except in the case of wireworm ravage in the north. A mild and moist winter was followed by luxuriant vegetation in leafage of trees and wild plants (as shown in the general returns from many of the stations of the Meteorological Society), as well as in the crops, and the rapid healthy growth proved of great service in keeping off insect attack. This may be observed especially in the coincidence of general moisture or showers at sowing time, with good turnip crops, but whether the effect lies in strong growth, keeping the plant ahead of the injury—"growing past" as it is technically termed—or in the state of the sap being less healthy to the insect feeder than the more condensed juices of drier seasons, requires to be more fully made out.

Several points of interest are recorded in the report for 1878, which has been recently issued, and which is published by Messrs. West, Newman, and Co., of 54, Hatton-garden. Thus, for instance, concerning the turnip fly (*Haltica nemorum*), it seems to have been scarcely seen at any of the localities, either in England or Scotland, from whence observations have been received. It is curious to note how weeds often act as food plants for insects, who, when the proper time arrives, transfer their attention to the more valuable food yielding plants. This is specially referred to in the case of the turnip fly, which was particularly destructive in the preceding year where charlock was prevalent. Reference is made to one district where charlock is so common, more or less plentiful indeed according to the amount of care bestowed by the farmer on his land, that some fields are quite yellow with it, while others are comparatively free, showing where one farm ends and the other begins. The reporter of these facts draws attention to the benefit of eradicating the food plant of the "fly" during the years in which the land is unoccupied by turnips, and thus preventing, or in some degree checking, its annual multiplication. From St. Alban's a report states that, as a general rule, where superphosphate or other special artificial manures are applied, with or without farmyard manure, turnips succumb less to the "fly" from the more rapid growth induced by their constituents being presented to them in a soluble and immediately available form. In the present season, a first sowing of swedes so treated, and accompanied by heavy rainfall at sowing time, turned out a splendid plant, untouched by "fly;" while, in the case of the later ones, where no artificial manure was used, and only a few showers occurred whilst they were coming up, the fly attacked and ruined half the crop. Observers are reminded that, "with regard to the spread of 'fly' from weeds, it would be very desirable to have some further notes of the extent to which it takes place, both from charlock and other wild plants." As another instance of the efficacy of manures, it is stated that two kinds of onions were sown in rows, along a bed of which half had been prepared in the usual way, with farmyard manure, and half deeply trenched, with no manure added. Both kinds of onions on the manured ground did fairly, and were uninjured, but on the unmanured ground the plants made no way, and were attacked by the maggot.

Regarding the carrot fly (*Psila rosae*), an observer at Dumfries mentions the fact that two-thirds of the crop is usually destroyed annually on light gravelly soil, but no damage is done on clay and moss land. He also mentions that he has found watering with paraffin oil, in the proportion of a wine glassful to a gallon of water, to be of use. Miss Ormerod further gives her experience of watering with a very dilute application of the fluid sold under the name of "Soluble Phenyle," by Messrs. Morris and Little, of Doncaster. She says, "towards the end of June the carrots in my garden at Isleworth were so severely attacked, that being past hope from any common remedy, I tried this fluid in various proportions, usually about a tablespoonful to a gallon of water, watering the ground frequently. The insect attack was very soon checked, and the plants started into healthy foliage, and the carrots that sprung on the infested ground after the application were straight and perfectly uninjured. How far the great luxuriance of leafage may tell on the formation of large roots remains to be seen by further experiment, but the check to the rust larvæ was complete. The main ingredient in this fluid is nearly allied to carbolic acid, and its use is chiefly as a disinfectant and for destroying parasitic attack in animals, but it appears to act as a stimulant to vegetation, whilst poisoning the insect feeder. Analysis of the roots shows such a small quantity of the chemical fluid to be absorbed as to be immaterial with regard to their subsequent healthiness as food. The use of any special application must, of course, remain doubtful, till it has been largely experimented with under different circumstances, but still, if we could gain knowledge of any application, fluid or otherwise, which by absorption into the plant would stimulate its growth without altering its desirableness for human food, whilst it preserved the vegetables from insect attack, it would be a great step onward. Larvæ will starve rather than feed on unsuitable food, and what is an almost imperceptible difference to ourselves appears to make all possible difference to them." With regard to the clouded yellow butterfly (*Colias edusa*) it seems to have been generally absent throughout the country, and totally absent from several localities where the previous season (1877) it occurred in great profusion. At Maldon, over an extent of one hundred and nine acres of clover and trefoil, where its great numbers in the preceding year might have given reason to expect it in abundance again, it was not observed at all. At Addington, Bucks, and Knebworth, Herts, it was similarly absent after numerous appearances, and at Maxwelltown, Dumfries (where it was observed in moderate numbers in 1877, after a sixteen years' absence), it is recorded as absent last season. At Isleworth and Norwich, where a few were noted in 1877, it was not observed at all in 1878. In the Exeter district, where the butterfly swarmed from June to September, in 1877, the first specimens seen last year were towards the close of July, and the autumn specimens were very rare.

A point of special interest in these observations is that referring to the importance of encouraging insectivora of all kinds, especially birds. It is reported

that the neighbourhood of Plymouth was exceedingly free from injurious insects, which is attributed to the mildness of the winter and amount of rainfall, and also the great number of migratory insectivorous birds, all on the look-out for larvæ and pupæ. Starlings are especially mentioned as congregating in such enormous quantities, that the great flocks coming in from all quarters of an evening to roost, and filling the trees, were noted as quite a sight. Amongst other birds that feed on insects, and should, therefore, be encouraged, are the swallow, martin, swift (said to feed on high-flying coleoptera), cuckoo (which feeds on lepidopterous larvæ, and more especially the hairy ones), all the warblers, the titmice, the woodpeckers, flycatchers, tree creepers, wrens, rails, and partridges; added to these may also be included the bats, the shrew mouse, and the mole; the latter especially plays his part as an insect-feeder to a greater extent than is usually supposed.

From the foregoing notes and extracts, the value of these annual reports will be readily understood.

AN ELECTRICAL WATER-LEVEL INDICATOR.

A new form of water-level indicator has lately been designed and constructed by the India-rubber, Gutta-percha, and Telegraph Works Company, Silvertown, and has been erected by them at the Leamington New Water Works, where it is stated to be giving every satisfaction.

These water works, which have within the last fortnight been opened and handed over to the Corporation of Leamington, were constructed by the firm of Messrs. Young and Co., of Nine-elms. The reservoirs from which the supply of water is distributed to the town, are situated some half mile from the pumping station, and it was therefore found necessary to have some kind of indicator placed at the engine house, in order to enable the man in charge of the engines to see at a glance the exact height at which the water stood in the reservoir, so that he might be able to regulate the rate of pumping accordingly.

The indicator that has been placed at the engine houses resembles somewhat in outward appearance an ordinary round metal case clock; the dial, instead of being divided into hours, minutes, &c., is divided into twenty equal divisions representing feet, and corresponding to the rise and fall that is required to be registered. A hand on the dial points to one of the divisions, which at any particular instant corresponds to the height at which the water in the reservoir stands. This hand, for every foot rise in the level of the water, moves an equal number of divisions round the dial; whilst, as the water falls, the hand turns back in the other direction, so that it always points to the exact height at which the water stands in the reservoir.

A single line of ordinary telegraph wire communicates between the indicator and the apparatus at the reservoir. This apparatus is so constructed that at every foot rise of the water, one pole of a battery is brought into connection with the line for a certain space of time, and the current from the battery actuating the indicator at the engine house causes the hand to move the requisite distance round the dial. On, however, the water falling, the opposite pole of the battery is brought into connection with the line, and this is made to cause the indicator hand to move in a contrary direction.

The apparatus at the reservoir is actuated by an ordinary float and weight in the water, and is arranged in such a manner that the battery contacts are always of the same duration, irrespective of the rate at which the water may be either rising or falling; this is a very important feature in the system, as it effectually prevents any undue waste of battery power, and hence a few cells of an ordinary Leclanché battery are found sufficient for the work. Both the indicator and contact apparatus are strongly constructed, and do not appear to be at all liable to any derangement, in fact, without some accidental breakage, such as the line getting knocked down, it should not under any circumstances show a wrong indication. The battery, being of the Lelanché form, should not require any attention for at least a year, when probably the renewal of some of the parts, at a trifling cost, would render the apparatus as effective as ever.

A variety of uses will at once suggest themselves to which this class of electric indicator might be advantageously applied, as it can be arranged, if required, to give a diagram on paper of the water level at stated intervals of time, instead of using a hand to point to the divisions on the dial, as in the present instance; also it is evident that it can quite as readily be made to give variations in inches as in feet. As a tide indicator, it might be made very serviceable on many of our large rivers, and probably ere long we shall hear of some further uses to which this novel application of electricity has been applied.

GENERAL NOTES.

New Regulations for Posting Printed Matter.—Dr. Playfair has given notice that, on Monday next, he will ask the Postmaster-General whether it is true that, after a period of five years, in which circulars printed by the electric pen, the papyrograph, and other mechanical means for producing numerous impressions rapidly, have passed through the post as printed matter at book-post rates, it has been intimated that this privilege will be withdrawn; and, if so, what compensating advantages are expected to accrue to the revenue and the public from restrictions which, in Dr. Playfair's opinion, are calculated to diminish the facilities of commerce.

The Australian Exhibition.—It is announced that her Majesty the Queen has been graciously pleased to give directions for the issue of a Royal Commission, of which his Royal Highness the Prince of Wales has consented to be the Executive President, in furtherance of the International Exhibitions about to be held in Sydney during the autumn of this year, and in Melbourne in 1880.

NOTICES.

LE NEVE FOSTER TESTIMONIAL FUND.

A list of subscriptions received up to Thursday morning last, since the last announcement, will be found on one of the advertisement pages of this *Journal*.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

April 2.—"Some Causes of the Recent Depression in Trade." By B. Francis Cobb, Esq., Treasurer of the Society.

April 23.—"English Fresh-water Fisheries." By J. Willis-Bund, Esq., Chairman of the Severn Fishery Board. Francis T. Buckland, Esq., M.A., H.M. Inspector of Salmon Fisheries, will preside.

April 30.—Renewed Discussion on Mr. John Holl-way's paper (read February 12) on "A New Process in Metallurgy." Prof. H. E. Roscoe, F.R.S., will preside.

African Section.

Tuesday Evenings, at Eight o'clock.

April 1.—1. "Remarks upon an Old Map of Africa contained in Sanson's Atlas, published in Paris in 1692," and exhibited by R. Ward, Esq.; and, 2. "South African Telegraphs," by J. Sivewright, Esq., Superintendent of Cape of Good Hope Telegraphs. W. H. Preece, Esq., will preside.

April 29.—1. "Light Railways for Opening-up a Trade with Central Africa," by John B. Fell, Esq.; and, 2. "The Advantage of Railway Communication in Africa, as compared with any other Mode of Transport," by J. Conyers Morrell, Esq.

May 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

Chemical Section.

Thursday Evenings, at Eight o'clock.

May 8.—"The History of Alizarine and Allied Colouring Matters, and their production from Coal Tar." By W. H. Perkin, Esq., F.R.S.

May 15.—Continuation of Mr. Perkin's paper.

Indian Section.

Friday Evenings, at Eight o'clock.

March 28.—"The Practicability and Advantage of a Ship Canal through the Island of Ramiseram." By Simon McBean, Esq., C.E.

May 2.—"The Wild Silks of India, especially Tussah." By Thomas Wardle, Esq.

Cantor Lectures.

Third Course, by W. H. Preece, Esq., on "Recent Advances in Telegraphy."

Lecture I.—April 21.

Definitions of telegraphy and electricity. Electrical effects. Sources of electricity. Economical distribution of electric currents.

Lecture II.—April 28.

The transference of electricity. Wires. Insulators. Supports. Gutta-percha, india-rubber. Underground wires and cables.

Lecture III.—May 5.

Simple telegraphy. Visual and aural signals. Telephones. Telegraphic writing.

Lecture IV.—May 12.

Duplex, quadruplex, multiplex, and harmonic telegraphy.

Lecture V.—May 19.

Automatic and fast-speed telegraphy.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon.....Royal United Service Institution, Whitehall-yard, 8½ p.m. Major C. E. Webber, "Orders in the Field, and the Means of Communicating Them." Illustrated by d'Arlincourt's telegraph.

Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. R. W. Tootell, "Hop Cultivation."

Chemical, Burlington-house, W., 8 p.m. Anniversary.

Institute of Actuaries, The Quadrangle, King's College, W.C., 7 p.m. Mr. T. B. Sprague, "The Construction of a Combined Marriage and Mortality Table."

Medical, 11, Chandos-street, W., 8½ p.m.

Tues.....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (African Section.) 1. "Remarks upon an Old Map of Africa Contained in Janson's Atlas, Published in Paris in 1692," and exhibited by Mr. R. Ward; and 2, Mr. J. Sivewright, "South African Telegraphs."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. A. Schäfer, "Animal Development." (Lecture XII.)

Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Discussion on "The Electric Light for Lighthouses."

Statistical, Somerset-house-terrace, Strand, W.C., 7¾ p.m. Mr. Stephen Bourne, "Some Phases of the Silver Question."

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Photographic, 5a, Pall-mall East, S.W., 8 p.m. 1. Resumed discussion on "Gelatine Emulsions." 2. Col. Stuart Wortley, "Samples of Pyroxyline."

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Prof. Flower, to exhibit and make remarks on a drawing of the Dolphin. *(Delphinus delphis)*. 2. Mr. Sclater, "Remarks on the Bird's-eggs collected during the *Challenger* Expedition." 3. Mr. R. Bowdler Sharpe, "A contribution to the Avi-fauna of the Zooloo Archipelago."

Wed.... **SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. B. Francis Cobb, "Some Causes of the Recent Depression in Trade."

Entomological, 11, Chandos-street, W., 7 p.m.

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. Thomas Morgan, "Etruscan Antiquities, and a Tomb recently found at Palestrina." 2. The Rev. S. M. Mayhew, "Ancient Teraphim."

Obstetrical, 53, Berners-street, Oxford-street, W., 8 p.m.

Royal College of Physicians, Pall-mall East, S.W., 5 p.m. (Croonian Lectures.) Dr. Bristowe, "The Pathological Relations of the Voice and Speech." (Lecture II.)

Thurs...Institute of Naval Architects (at the House of the Society of Arts), 12 a.m., Morning Meeting. 7 p.m., Evening Meeting.

Royal, Burlington-house, W., 8½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. Mr. John Miers, "Notes on *Moquilea*, &c."

Chemical, Burlington-house, W., 8 p.m. 1. Dr. Tilden, "Terpin and Terpinol." 2. Messrs. R. S. Dale and C. Schorlemmer, "The Transformation of Aurin into Trymethylpararosaniline." 3. Mr. Attwood, "A Gold Nugget from South America." 4. Mr. G. C. F. Cross, "The Solution of Aluminium Hydrate by Ammonia, and a Physical Isomeride of Alumina."

South London Photographic (at the House of the Society of Arts), 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Tyndall, "Sound." (Lecture VIII.)

Royal Society Club, Willis's-rooms, St. James's, S.W. 6 p.m.

Archæological Institution, 16, New Burlington-street, W., 4 p.m.

Fri ......Royal College of Physicians, Pall-mall East, S.W., 5 p.m. (Croonian Lectures). Dr. Bristowe, "Pathological Relations of the Voice and Speech." (Lecture III.)

Institute of Naval Architects (at the House of the Society of Arts), 12 a.m., Morning Meeting. 7 p.m., Evening Meeting.

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meetings, 9 p.m. Mr. William Crookes, "Molecular Physics in High Vacua."

Geologists' Association, University College, W.C., 8 p.m.

Philological, University College, W.C., 8 p.m. A Classical Paper by Prof. Goodwin.

Sat......Institute of Naval Architects (at the House of the Society of Arts), 12 a.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. F. Seymour Hayden, "Etching." (Lecture III.)

JOURNAL OF THE SOCIETY OF ARTS.

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FRIDAY, APRIL 4, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

APPOINTMENT OF ASSISTANT-SECRETARY.

At their meeting on Monday last, the Council appointed Mr. H. B. Wheatley (clerk to the Royal Society) to the post of Assistant-Secretary of the Society of Arts.

INSTITUTIONS.

The following Institution has been received into Union since the last announcement :—

Science and Art Classes, St Helen's, Lancashire.

AFRICAN SECTION—CHEMICAL SECTION.

The reports of the last meetings of the above Sections have been kept over until next week. They will, therefore, appear in the next number of the *Journal*. The papers read were "The Inoxidation of Iron and the Coating of Metals and other Surfaces with Platinum, by the Processes of Mons. Dodé," by L. M. Stoffel, C.E., in the Chemical Section; and "Remarks on an Old Map of Africa, contained in Sanson's Atlas, published at Paris in 1692," exhibited by R. Ward, on behalf of the owner; and "South African Telegraphs," by J. Sivewright (General Manager of Telegraphs in South Africa), communicated by Robert James Mann, M.D., in the African Section.

ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1879, early in May next. This medal was struck to reward "distinguished merit in promoting Arts, Manufactures, or Commerce," and has been awarded as follows :—

In 1864, to Sir Rowland Hill, K.C.B., "for his great service to Arts, Manufactures, and Commerce, in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefits of which have, however, not been confined to this country, but have extended over the civilised world."

In 1865, to his Imperial Majesty, Napoleon III., "for distinguished merit in promoting, in many ways, by his personal exertions, the international progress of Arts, Manufactures, and Commerce, the proofs of which are afforded by his judicious patronage of Art, his enlightened commercial policy, and especially by the abolition of passports in favour of British subjects."

In 1866, to Professor Faraday, D.C.L., F.R.S., for "discoveries in electricity, magnetism, and chemistry, which, in their relation to the industries of the world, have so largely promoted Arts, Manufactures, and Commerce."

In 1867, to Mr. (now Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S., "in recognition of their joint labours in establishing the first electric telegraph."

In 1868, to Mr. (now Sir) Joseph Whitworth, F.R.S., LL.D., "for the invention and manufacture of instruments of measurement and uniform standards, by which the production of machinery has been brought to a state of perfection hitherto unapproached, to the great advancement of Arts, Manufactures, and Commerce."

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For.Memb.R.S., Chevalier of the Legion of Honour, &c., "for his numerous valuable researches and writings, which have contributed most importantly to the development of food economy and agriculture, to the advancement of chemical science, and to the benefits derived from that science by Arts, Manufactures, and Commerce."

In 1870, to M. Ferdinand de Lesseps, "for services rendered to Arts, Manufactures, and Commerce, by the realisation of the Suez Canal."

In 1871, to Mr. (now Sir) Henry Cole, C.B., "for his important services in promoting Arts, Manufactures, and Commerce, especially in aiding the establishment and development of International Exhibitions, the development of Science and Art, and the South Kensington Museum."

In 1872, to Mr. Henry Bessemer, "for the eminent services rendered by him to Arts, Manufactures, and Commerce, in developing the manufacture of steel."

In 1873, to M. Michel Eugène Chevreul, For.Memb.R.S., "for his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world."

In 1874, to Dr. W. C. Siemens, D.C.L., F.R.S., "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the Arts; and for his improvement in the manufacture of iron; and generally for the services rendered by him in connection with economisation of fuel in its various applications to the Manufactures and the Arts."

In 1875, to M. Michel Chevalier, "The distinguished French statesman, who, by his writings and persistent exertions, extending over many years, has rendered essential service in promoting Arts, Manufactures, and Commerce."

In 1876, to Sir George B. Airy, K.C.B., F.R.S., the Astronomer Royal, "for eminent services rendered to Commerce by his researches in nautical astronomy, and in magnetism, and by his improvements in the application of the mariner's compass to the navigation of iron ships."

In 1877, to Jean Baptiste Dumas, For.Memb.R.S., member of the Institute of France, "the distinguished chemist, whose researches have exercised a very material influence on the advancement of the Industrial Arts."

In 1878, to Sir Wm. G. Armstrong, C.B., F.R.S., D.C.L., "because of his distinction as an engineer and as a scientific man, and because by the development of the transmission of power—hydraulically—due to his constant efforts, extending over many years, the manufactures of this country have been greatly aided, and

mechanical power beneficially substituted for most laborious and injurious manual labour."

The Council invite members of the Society to forward to the Secretary, on or before the 26th of April, the names of such men of high distinction as they may think worthy of this honour.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference will be held in the Rooms of the Society of Arts, on Thursday and Friday, the 15th and 16th May, 1879, on National Water Supply, Sewage, and Health, the Right Hon. James Stansfeld, M.P., late President of the Local Government Board, in the chair, assisted by the members of the Executive Committee:—Lord Alfred Churchill (Chairman of Council); Sir Henry Cole, K.C.B.; Colonel Sir E. Du Cane, K.C.B.; Captain Douglas Galton, C.B., F.R.S.; Mr. F. A. Abel, C.B., F.R.S.; Mr. T. W. Keates; Dr. Voelcker, F.R.S.; Mr. W. Hawes, F.G.S.; Major-Gen. F. Cotton, R.E., C.S.I. Papers relating to the above subjects will be read and discussed.

Programme of Proceedings.

The Conference will meet each day at 11 a.m., and sit till 1.30, then adjourn till 2, and sit again till 5 p.m., and, if necessary, meet again at 8 p.m.

Thursday, 11 a.m.—Opening of the Proceedings by the Chairman.
Papers and Discussion.

Friday, 11 p.m.—Proceedings will be resumed.
Papers and Discussions continued.

There will be an Exhibition of Mechanical and Chemical Apparatus in connexion with Water Supply, Treatment of Sewage, and Health. All articles for exhibition must be delivered, carriage free, not later than Saturday, the 10th May, 1879. Manufacturers and others desiring to exhibit should communicate forthwith with the Secretary of the Society of Arts.

Papers on any of above heads are requested.

The object of the Conference is to discuss existing information in connexion with the results of any systems already adopted in various localities, referring to the subjects of National Water Supply, Sewage, and Health; to elicit further information thereon; and gather and publish, for the benefit of the public generally, the experience gained. The introduction and discussion of untried schemes will, therefore, not be permitted. The papers accepted for the Conference will be printed and circulated at the Meetings.

Prize Medals.

1. The Council of the Society of Arts offers one Gold and three Silver Medals for the best suggestions, founded upon evidence already published, for dividing England and Wales into districts, for the supply of pure water to the towns and villages in each district.

2. The districts should be laid out on a skeleton map scale, which can be obtained from Mr. Stanford, 55, Charing-cross, price 6d. each.

3. The average rainfall in the district should be stated; also the population of the district, and its geology.

4. The suggestions should be written on foolscap, half-margin, and sent, accompanied by maps, under cypher, to the Secretary of the Society of Arts, on or before the 26th day of April, 1879.

5. The maps will be exhibited, and the suggestions will be discussed at the Conference on National Water Supply.

6. The Council will invite the assistance of eminent authorities to recommend the competitors worthy to receive the prizes; but the prizes will be withheld if the suggestions made do not appear to the judges to be of sufficient merit.

INDIAN SECTION.

Friday, March 28; Sir James Elphinstone, Bart., M.P., in the chair.

The paper read was—

THE PRACTICABILITY AND ADVANTAGE OF A SHIP CANAL THROUGH THE ISLAND OF RAMISERAM, BETWEEN INDIA AND CEYLON.

By S. McBean, A.M.I.C.E.

During the many years we have held and ruled India, very little seems to have been done to provide for the greater convenience of its external communications, although we have spent more than £100,000,000 in developing the internal railway communications alone of the vast territory, embracing 1,500,000 square miles and 240,000,000 people. With the single exception of Kurachee Harbour, and perhaps Bombay, there is nothing to show in the shape of good harbour accommodation, safe of access in any weather, and where repairs and refitting can be executed. There are only two or three dry docks in all India, and it is not too much to say that if some of the money so lavishly expended in providing railway communication had been spent in improving and providing harbour accommodation round 4,000 miles of coast line, the external trade of India would be in a much more prosperous condition than it is now.

There can hardly be a more unfavourable view of our rule in India than the present condition of its natural harbours, which are not numerous, after so many years' investigation and so many laborious reports. What would Great Britain have been without its numerous artificial harbours and docks? Certainly, not the mart of the world.

The roads, the rivers, he canals, and the irrigation of India have been vastly improved during recent years, and 7,000 miles of railway have been con-

structed almost within a quarter of a century, but the harbours have been sadly neglected, although an expenditure of £5,000,000 would be of vast benefit, in improving good harbours and opening up and constructing minor ones, at a dozen places round the enormous stretch of coast line. Many able reports have been written for the Indian Government, pointing out how improvements can be effected in the general harbour accommodation; but Kurachee, Bombay, and Madras alone indicate that active steps have been taken by the Government to make these ports easily accessible, and convenient for loading and unloading in any weather.

Calcutta is the only great port where a justifiable excuse exists, on account of the insuperable difficulty of dealing with continually shifting sand banks, the great floods, and tides. In consequence of the vast development of commerce through the construction of roads, canals, and railways, and the prosperous results of the cotton, coffee, and tea enterprises, good harbours are now a much greater necessity to the South of India than formerly, and in spite of the annually recurring famines, one to two millions should be expended every year for the next ten years on reproductive works, creating good harbours and improving bad ones. Every one of these works would repay itself within 20 years, besides being of immense service in developing the country in its immediate neighbourhood, and thereby the railway traffic and external trade of India would be greatly increased.

Instead of half-a-dozen far-distant ports in 4,000 miles of coast line, there should be facilities of shelter offered to storm-driven shipping at every 200 miles of coast at least.

Another view of the subject is that, with good well-sheltered ports, the native fishing-trade along the coast would greatly prosper, and in times of distress, owing to a bad harvest, increased facilities would be afforded of supplementing the usual scanty diet by the daily harvest reaped from the sea. The Indian coasts are swarming with fish, and improved harbour accommodation would lead to more extensive fishing throughout the year, tending to greater abundance of the general supply, thus cheapening an article that enters largely into the diet of vast numbers of the population. When the harvest failed through want of rain, an ample supply of fish would go far to mitigate distress and keep down the price of rice over a great extent of country.

It need not be doubted that an increased harbour accommodation, affording greater facilities and conveniences to shipping in loading and unloading during any weather, would mean increased prosperity, more or less, to all India, as the interior would be re-acted upon from every port on the coast, and all would experience the benefits of the harbours created around the extensive seaboard.

Another view of the subject is that naval stations should be established at suitable intervals around the coast, where any ships in distress could run for refuge or repair, instead of being compelled to go to Trincomalie or Bombay, at great expense.

The future is more pregnant in this respect than the past, on account of the annually increasing trade, and we must be better provided for the naval defence of India, by constructing good harbours all around the coast wherever they are feasible and necessary.

When the Colombo breakwater and harbour are completed, a place of safety of enormous importance will have been created, at a cost of about one million sterling, having a carrying trade of about £8,000,000 sterling annually. Much of this trade is with India, and it is pitiable to think that Ceylon, with a revenue of £1,500,000, and a population of two-and-a-half millions, will be in posession of a breakwater and harbour, superior to any India will possess, with a revenue of £59,000,000, and a population of 240,000,000, and a trade 20 times as much. Our Indian rulers have not done their duty in so long ignoring the importance of speedily providing ample harbour accommodation for the external trade of our Indian empire, and the greater safety and convenience of all shipping resorting to those waters, for repairs as well as trade.

In connection with the improved harbour accommodation of all India, the improvement of the navigation round the south of India, between it and Ceylon, has occupied, more or less, the attention of the authorities of both countries during the last 50 years.

The Gulf of Manaar, Adam's-bridge, Palk's Straits, and Point Calimire Reef extend between the Arabian Sea and the Bay of Bengal, separating India from Ceylon. The islands and reef dividing the Gulf of Manaar from Palk's Straits are low-lying, deep water being generally at a few miles out on the south side, but the north side is generally comparatively shallow all over Palk's Straits. There are indications that Ceylon was at one time joined to the mainland. Between the spit of Ramnad and the Island of Ramiseram a tortuous channel had from a remote time existed, which was formerly about 7 ft. deep, and has within a few years been deepened to 12 ft. and 14 ft., at a considerable outlay. Another channel exists between Manaar Island and Ceylon, but it is very shallow, fit only for native boats of small size.

The entire distance from Point Tonitory, in India, to Ceylon is about 56 miles, and in that length there is only one spot well sheltered, with deep water close to both shores, where a ship canal can be economically constructed from the Gulf of Manaar into Palk's Straits, affording direct communication with the Bay of Bengal. The shipping now using the Paumben Passage amount to 2,000 or 3,000 vessels annually, with a tonnage of 200,000. The expense of deepening and keeping open this Paumben Passage has been about £50,000, and as a toll is exacted, no doubt the work has been directly remunerative, as well as affording immense convenience to the trade of Southern India and Ceylon, but it is simply of local importance.

The length of the Paumben Passage is seven miles, between 30 feet soundings, and on account of its length, tortuous character, and liability to silt up from cross currents, it has not been deemed advisable to adopt it as the site of the proposed ship canal and port for Southern India. By cutting a ship canal between India and Ceylon, and enlarging it on the low lying portion of the Island of Ramiseram into a harbour of suitable extent, a vast improvement would be effected in the circumnavigation of India, and in providing a shorter route between Ceylon and India, and for the European trade with Ceylon, Madras, and Calcutta, than that round the south of Ceylon.

It must not be forgotten that the Ramiseram Canal can be enlarged at a small extra cost into an artificial harbour and dock, capable of being in railway communication with India and Ceylon.

Mr. Robertson, in his report on the Ramiseram Canal, says:—"This is, however, only a question of money, because it would be quite easy to connect the canal at Ramiseram with a railway to the mainland; and, indeed, for that matter, Ceylon and India might easily and cheaply be joined together by rail along Adam's-bridge, for the water in the openings between the sand banks is very shallow, and the banks are very flat." It is thus clear that the design would be equally serviceable to Ceylon and India, since cargoes can be discharged at the Ramiseram docks and forwarded East or West, that is to India or Ceylon, the railway spanning the ship canal by a swing bridge. The cost of such a line would be no more than £10,000 per mile, and would be of immense service in developing Southern India and the Northern Province of Ceylon, which is capable of supporting a dense population under proper cultivation. It is now mostly given over to jungle and wild beasts, but there is much good soil, fit for growing rice, cotton, cinnammon, other spices, and cocoanuts. There is no want of water, as streams are more numerous than in India, where famines are becoming chronic through scarcity of water. The union railway will, no doubt, be instrumental in introducing colonists from overstocked India to deserted Northern Ceylon. The jungle fever only prevails until cultivation has obtained the sway over the existing jungle, and after the land has been cleared the prevailing sickness will disappear.

It is melancholy to read of famines in India, through overstocked population and want of water, year after year, costing the Government millions of sterling; and to know that the Northern and Eastern Provinces of Ceylon contain millions of acres of fertile, uncultivated land, capable of being irrigated all the year round at a small outlay, and producing the most luxuriant crops. The construction of the railway would be of immense benefit to the trade of Ceylon and India, and would be instrumental in the hands of the respective Governments towards opening out the vast tracts of rich waste lands. Prosperity in India and Ceylon means prosperity to the Ramiseram Canal and Docks in conjunction with the Union Railway, all working harmoniously together to maintain our prosperity and supremacy as a governing race. We are bound to utilise our means, and govern for the advantage of those entrusted to our care, and here is one noble instance where incalculable benefits can be bestowed upon all Eastern trade and shipping, as well as Southern India and Ceylon, through the opening of this canal, docks, and railway. They will not prove unproductive schemes even at the outset, but, from the moment of their commencement, will provide labour for many thousands of people who are starving, and afterwards maintain a large staff of natives in employment, returning a handsome per-centage on the outlay. The increased facilities which will be afforded to shipping of every kind will give an impetus to the coast trade of Ceylon and India, as well as the European trade with Madras, Calcutta, and Rangoon. Coaling will be found convenient at Ramiseram, and the opening of the canal may be the means of developing the Indian coal-fields in addition to other mineral productions, and also the cotton, coffee, and tea cultivation in the South of India.

Ceylon has a population of 100 to the square mile, India 160 to the square mile, and the former has fewer absolutely arid desert spots in comparison than the latter. Taking it all in all, Ceylon is capable of sustaining a population of at least six millions of people, and there is unquestionably room in the Northern and Eastern Provinces for some of the surplus starving population of India. The emigration from India to Ceylon has been delayed through the want of adequate ports on the South of India, and proper communication in Ceylon. The Indian coolies required for the cultivation of the Ceylon coffee estates number 200,000 to 300,000, and the same class of immigrants would be glad to cultivate land on their own account, under a proper settlement, in the waste places indicated. The railway to connect Ceylon and India would run through the heart of the Northern Province by the ancient capital, Anuradhapura, the city of ruined temples and palaces, more than 2,000 years old. The port and canal of Ramiseram, in conjunction with the railway, will give easy access to this fine, but long-neglected county. Incursions of the fierce tribes of Southern India, more than 300 years ago, ruined this rich, cultivated country, and it has remained ever since neglected, and has relapsed into jungle. Let the peaceful immigration from the same territory be instrumental in reviving the old industry, with improved modes of cultivation, under happier auspices, and without fear of robber tribes depriving the cultivators of the fruits of their labour.

We have had Ceylon in our possession more than 80 years, yet not much has been done for the reclaiming of its waste places in the Northern Province, many of which must be exceedingly fertile. The Indian and Ceylon Governments working together can do much to bring about so desirable a consummation, which will benefit both countries to an enormous extent, in many more ways than can now be indicated.

India is assailed year after year with famines through want of water and a too redundant population, bringing heavy burdens and deficits on its revenue, and steadily increasing its debt. These railway and canal works will be quite as remunerative undertakings as the railways generally now are, and absolutely necessary to be commenced at an early date, in the combined interests of Ceylon and India. In the matter of the railway, I am sure that the Ceylon Government would be quite willing not only to construct the line from Matali to Manaar in Ceylon, but halfway across the reef to India, a total distance of 160 miles, because the benefits would be far more than would counterbalance the necessary outlay, which to Ceylon would be, for a railway on the same broad guage, £1,500,000. The unfortunate part of it is that the Southern Extension of India is made on the narrow gauge, and Ceylon railways are constructed on the Indian 5′ 6″ gauge, thus causing a break of gauge, which should terminate at Point Tonitory in Ramnad. The cost of prolonging the South Indian line to that point, and constructing the line half-way across Adams'-Bridge, a distance of about 130 miles, would be about £1,000,000. There would be sufficient traffic on this railway,

between India and Ceylon, and to the Ramiseram Canal and port, to make it pay 10 per cent. after a time. There can be no doubt in the mind of anyone who has studied this subject of intercommunication between Ceylon and India, that it is now in a very unsatisfactory state, and that it is possible to bring about an enormous advantage to both countries by a most remunerative outlay, undertaken at a time of cheap labour and cheap materials of every kind requisite for carrying on such a work.

Our Indian Empire has, roughly speaking, a coast line of 4,000 miles from Kurachee to Rangoon. In this enormous stretch of seaboard there are only three first-class ports where shipping of any tonnage can load or unload in safety; Kurachee, Bombay, and Calcutta, with minor ports for native craft and sailing ships at Poshetra, Seria, Shalbet, Jyghur, Viziadrug, Karwar, Cochin, and Kolachul, on the western side, capable of being converted into good harbours. Bombay harbour is the best on the west coast, but still requires great improvement to make it thoroughly convenient for loading, unloading, and repairing. The backwater from Beypur to Trivandrum, with three to eight fathoms depth, would form one of the most secure harbours in the world in connection with Cochin.

On the eastern coast, Tuticorin is the first harbour of importance beyond Cape Cormorin, and here ships are obliged to lie 2½ miles off the shore. Port Lorne, south of the Ramnad promontory, is a completely sheltered expanse of water, seven miles long by four miles wide, with a depth of 20 ft. to 30 ft.; but the entrance to it has no more than 15 ft. of water, and would always require dredging to keep it open to a greater depth. If this entrance were dredged out to 30 ft. there would be a splendid harbour created for shipping the produce of southern India; jetties extending to deep water would be, however, rather costly.

The Paumben Passage, from the Gulf of Manaar into Palk's Straits, is unsuitable for a harbour, although it has been recommended by Mr. Townshend to be deepened to 26 ft., to pass ocean steamers (being one of the rejected proposals put forward as the subject of this paper), which the Government has not approved of, for satisfactory reasons, the economical one being chief, no doubt.

North of Ceylon, Negapatam first claims our attention, but it is generally considered incapable of improvement. The possibility of improving Madras Harbour remains undecided, and it is problematical whether any permanent benefit can be effected for the better accommodation of shipping, beyond affording partial shelter.

Between Madras and Calcutta there is no existing harbour, and there are only two spots where sheltered water can be obtained, after embarking in a lavish expenditure, with the exception of False Point, at the mouth of Mahanadi. The improvement of the Hooghly is attended with great difficulties, owing to the immense volume of water, the bore, and floods bringing down enormous quantities of silt. All of the existing harbours require great improvements effected, and new ones require to be constructed wherever feasible, to carry on the coast and ocean trade adequately to the requirements of so great and prosperous a country as India, with an export and import trade of £112,000,000, and a coast trade nearly half as much. Both the foreign trade on the east coast, and a great portion of the whole coast trade, is hampered by the inadequacy of the Paumben Passage, to pass vessels drawing more than 12 feet of water, without unloading and reloading on the other side. All ships drawing more than 12 feet must unload in barges at one end, and reload at the other end of Paumben Channel, or proceed on the voyage round the south of Ceylon, being from 350 to 360 miles longer than the distance by the Paumben Channel. This is a very serious matter in stormy weather, prevailing so many months in the year in this quarter.

The enormous annual saving that would result in actual economy of working and in prevention of shipwreck would soon pay for the construction of a ship canal between India and Ceylon, affording a voyage of 200 miles in much calmer water throughout, instead of fierce battling in a raging sea for 560 miles. Vessels after touching at Colombo, soon to be converted into a magnificent harbour with a breakwater one mile in length, would be enabled for one half the year to avoid the terrible south-west monsoon round the south of Ceylon, and would make for the canal mouth with a fair wind. The voyage from Madras to Colombo would be more favourable, through the ship canal for nearly the whole length, as Southern India and Ceylon itself shelter the new route, both in south-west and north-east monsoons. The sailing ships round the Cape to Madras, Calcutta, and Chittagong, would also find it considerably shorter.

The southern coast of Ceylon has proved perilous to many, and totally destructive to not a few good ships during the last twenty years, notwithstanding the lights on the Great and Little Basses; and all classes of ships must give it a wide berth. The Peninsular and Oriental Steam Navigation Company have substantial reasons for avoiding it in future, and indeed all the great steamers that now call at Colombo would gladly do so likewise if a safe passage could be effected between India and Ceylon. For the development of the coast trade, and affording it greater facilities, and for the economy, convenience, and safety of the ocean shipping, the construction of a canal and port, at a cost under a million sterling, is absolutely essential, and must be carried out speedily, in the interests and for the continued prosperity of Indian and Ceylon commerce.

The principal difficulties to contend with are, the selection of the most suitable site from so many proposals and reports, at variance with each other, furnished during the last twenty years; and the provision of the funds to carry out the design proved to be the most feasible, with a due subservience to economical considerations, within reasonable bounds, keeping in view the great gains.

Between £90,000 and £2,372,810, the amounts of the lowest and highest estimates for the contemplated work, there is a tremendous disproportion. The former refers to an unprofessional estimate of the Port Lorne site; the latter to Sir William Denison's site, as estimated by Mr. Townshend, superintendent of Plymouth Breakwater.

The various practicable proposals lie within a

distance of about 25 miles from east to west, and are as follows:—

1. Commander Taylor's proposal through Ramnad peninsula, eight miles west of Point Tonitory, costing £1,750,000, as estimated by me.

2. Deepening present Paumben Channel, by Mr. Townshend, Plymouth, costing £1,386,000.

3. Through Ramiseram Island, one mile east of Paumben, by Mr. Robertson, Edinburgh, costing £440,000.

4. Through Ramiseram Island two miles east of Paumben, by Mr. John Stoddart, chief Assistant Surveyor to Surveyor-General of Ceylon, costing £356,000.

5. Through Ramiseram Island, three miles east of Paumben, by Sir. William Denison, costing £2,372,000, including breakwater.

Any other proposed routes between Ceylon and last mentioned are impracticable, from exposed entrances and long shallow approaches in Gulf of Manaar and Palk's Straits.

The first is $7\frac{1}{2}$ miles long between five fathom soundings, $2\frac{3}{4}$ miles of which are through dry land, with indications of rock of a hard character.

The next is about the same length in a winding direction, entirely in the open sea.

Mr. Robertson's route is five miles in length, between five-fathom soundings, but has the natural shelter of Shingle and Cooresuddy Islands on its southern side.

Mr. Stoddart's is only three miles long, between five-fathom soundings, and almost equally well-sheltered with the previous by the same islands, which fact Mr. Robertson admits in his report upon the subject.

Sir Wm. Denison's proposal is the same length as the previous one, but is beyond the shelter of the Shingle Islands, and would, therefore, require the construction of a breakwater in 25 ft. to 30 ft. water to protect its southern entrance, at a cost of £1,000,000, as estimated by Mr. Townshend, giving a total of nearly seven times as much as the preceding proposal, and, therefore, condemnatory of the adoption of this site as a suitable one for the proposal canal.

Many valuable reports have been written on this important question of a ship canal between Ceylon and India, but no action has hitherto been taken, beyond deepening the Paumben Channel to 12 ft., and expending a few thousands annually in keeping it clear, for the passage of native craft and the Ceylon Government steamer *Serendib*, the only steamship that can use it in these waters.

The Parliamentary Committee of 1862, recommended a site almost identical with that selected by Mr. Stoddart, and after investigation into all the proposals extending over a period of seven years, I have arrived at the conclusion that it is the best site that can be adopted, both for economy and general suitability for the purpose in view. Mr. Robertson, after personal inspection, selected a site entailing two miles more deepening, but having rather less dry land cutting, not any better sheltered either on north or south side. The small amount of dry cutting captivated him, in my opinion. Those designs entailing long deepening in the open sea, and the construction of an artificial breakwater, may at once be dismissed as being too costly originally, and in maintenance afterwards. Of these classes are Mr. Townshend's for long open sea deepening through present Paumben Channel, and Sir William Denison's through Ramiseram Island, three miles east of Paumben entailing construction of breakwater. The consideration of the subject is thus narrowed to Port Lorne, with canal through the Ramnad promontory; Mr. Robertson's proposal one mile east of Paumben; and Mr. Stoddart's proposal two miles east of it. The dry land cutting through the Ramnad promontory design is nearly three miles long, deepening to five fathom soundings nearly three miles on each side, and a cut through a bar to obtain an entrance into Port Lorne, quite one mile long, between five-fathom soundings, and subject to cross currents and silting up. The dry land cutting is said to be through harder sandstone than is found on Ramiseram, and the general depth of it is greater. It is through 30 feet sand hills and much sandstone at water level. This scheme would, in my estimation, cost a million-and-a-half sterling at least, and may therefore be put on one side without more ado, as impracticable on account of great original cost and prospective annual outlay in maintenance, notwithstanding the immense expanse of sheltered water that would be afforded. The Port Lorne site for canal is clearly unsuitable as well, because there is no natural shelter at the northern or Palk's Straits entrance, and to create an artificial one would, as shown in the case of Sir W. Denison's site, be very costly, as the surf beats heavily on the northern shore of Ramnad promontory. As a port for Ramnad, Port Lorne is admirably situated, and no doubt advantage will be taken of the position to give the territory of Ramnad a secure harbour at a comparatively small outlay, which will not be difficult of access, even now to shipping, drawing no more that 12 feet of water. What India pre-eminently requires wherever it can be economically obtained, are landing wharves, without the necessity of using cargo boats. It will thus be evident that although there is an immense expanse of sheltered water, called Port Lorne, which is the southern entrance to the canal as proposed by Commander Taylor, the site is not the best for this project, on account of the length of the cutting and deepening, very much more than is required at Ramiseram, which also has an expanse of sheltered water at both entrances, while the other is totally destitute of natural shelter in Palk's Straits. The expense of the Ramnad promontory design, too, is immensely greater than what will be necessary at Ramiseram, two miles east of Paumben. Both Commander Taylor and his supporters have evidently been fascinated by the great expanse of sheltered deep water at Port Lorne, in fixing upon it as the site for the canal, forgetting that the dry land cutting and the deepening are each more than twice as much as at Ramiseram, and that the northern entrance to canal proposed by them would be quite exposed in the north-east monsoon, rendering the canal entrance difficult of access, and always liable to silt up. On the other hand, the bulk of the evidence is in favour of the position at Ramiseram, being entirely free from silt, and quite sheltered in both monsoons in the Gulf of Manaar and Palk's Straits.

We now come to Mr. Robertson's proposal to cut the canal through Ramiseram Island at a low lying portion of it, one mile east of Paumben Town. The

southern entrance is in 23 feet of water, but perfectly sheltered in the south-west monsoon by Shingle and Cooresuddy Islands, between which the reef extends, a few feet down below surface of water. The northern entrance is in 30 feet of water at a distance of $1\frac{1}{4}$ mile away from the shore, and is sheltered to some extent from the north-east monsoon by a projecting portion of Ramiseram itself. The southern entrance requires deepening in a cross current at least for 2 miles beyond the 23 feet sounding to 30 feet of water, making the entire length of canal 6 miles, being $2\frac{1}{8}$ miles through dry land and $3\frac{7}{8}$ of deepening from low water to 30 feet soundings. The dry land is composed of sand and soft sandstone, of an average depth of 35 feet from surface of ground to bottom of canal, which would have 26 feet of water through the island and 30 feet at entrances. Mr. Robertson's estimate for the canal on this site is, including all contingencies, £440,000, but I do not think that he includes fully two miles of deepening for a width of 300 yards in the Gulf of Manaar—which must be executed to ensure safety of navigation—in this amount, and which would probably add £100,000 more to his calculations, making the total for a perfect canal capable of passing one ship at a time only, £540,000. I do not doubt but the canal could be executed for that amount, and maintained in this position at a very reasonable annual expenditure considering the silting up from currents inevitable. The excavation will generally be of an easier description further away from Paumben than is Mr. Robertson's site for a canal.

The last proposal to be considered is that of Mr. Stoddart, chief assistant to the Surveyor-General of Ceylon, who was engaged in surveying the Paumben Channel, Ramiseram Island, and Port Lorne, at the request of Messrs. Townsend and Robertson, by order of the Ceylon Government. He recommended a site through Ramiseram, about one mile eastward of that proposed by Mr. Robertson, and about two miles east of the town of Paumben, after long practical experience and observation of tides, currents, monsoons and their effects, both in the Gulf of Manaar and Palk's Straits. The land does not lie quite so low as at Mr. Robertson's site, but the deep water is much nearer the shore, both in the Gulf of Manaar and Palk's Straits, being nearly the same as Sir W. Denison's, a fact of immense importance in construction and maintenance and the safe navigation of the canal from end to end. This position is sheltered on the south side by the same islands, Shingle and Cooresuddy, that afford shelter to Mr. Robertson's proposed entrance, and the northern entrance is still better sheltered than Mr. Robertson's by the same projecting headland of Ramiseram. The distance between five fathom soundings at this site is just $3\frac{2}{5}$ miles, or 6,000 yards, and across Ramiseram and between low water levels is about $2\frac{1}{8}$ miles. For a canal wide enough throughout for two ships to pass each other, the estimate for this route, prepared under my own supervision, amounts no to more than £550,000, and for a single ship canal, of the same dimensions as Mr. Robertson's, with a base of 72 feet, the same as that of the Suez Canal, the total amount of estimates, including lighthouses at entrances, is but £356,000. To this amount, as to all the projects, must be added a sum of £30,000 for light ships and buoying the channel over patch north-west of Kara Teevo Island, west of Jaffna peninsula, and also patch north of Point Pedro, at northern entrance to Palk's Straits. Everyone who reported on this project, so far as I am aware, save Commander Taylor, ignored this supplementary work, which, however, is absolutely necessary to ensure the safety of navigation of large steamers by this route in rough weather over these shoals off Point Pedro and Kara Teevo, where no more than 24 to 27 feet of water exist at low water. The Admiralty chart indicates these shoals, and their lighting and buoying must, of course, be included in any project which claims to be perfect, for improving and ensuring the navigation between Ceylon and India. A lighthouse would also be required on the headland of the island of Kara Teevo, north-west of Jaffna. The entire distance from the open sea in the Gulf of Manaar to the same in the Bay of Bengal would be about 90 miles, or from Cape Comorin to Point Pedro 200 miles, while the distance round Ceylon from Comorin to Point Pedro is 560 miles, showing a saving in favour of the canal of 360 miles, besides having a comparatively calm sea through the Gulf of Manaar and Palks Straits instead of the tempestuous and dangerous voyage round the south of Ceylon, as already pointed out.

Having thus carefully considered all the designs put forward, their advantages, cost of construction, and maintenance, as well as convenience and accommodation for the Indian trade, local and foreign, it may safely be assumed that the position for the ship canal chosen by Mr. Stoddart is unquestionably the most suitable and economical for all interest involved. The approaches in both monsoons are quite safe, well sheltered, and comparatively free from cross currents which would tend to silt up the entrances, and entail considerable annual expense in dredging.

Mr. Robertson stated that the time required to construct the canal on his site would be four years, and as the difference between the two is of trifling importance, so far as the amount of dry cutting and shore dredging is concerned, the canal on Mr. Stoddart's site can easily be completed in the same period of time. He says, likewise, respecting the Ramiseram sites, and he is a competent judge:—

"The line selected by me represents what I consider the most favourable position as regards shelter; but any canal between Mr. Stoddart's line and mine would have its southern entrance fairly sheltered. Any line between his line and Sir William Denison's would be too much exposed. It is very probable that further examination during the height of the south-west monsoon may lead to the final fixing of a medium line between mine and Mr. Stoddart's, in which case my estimate will be more than ample."

Mr. Robertson's opinion with respect to this site is that no rock exists to the depth of 30 feet, and along the line of soundings in Palk's Bay there is a little soft coral in the bed of the sea, about three or four feet deep. The information obtained by borings appears to indicate that no difficulty is likely to occur, either as regards dredging or excavation, through the island. In another part of his valuable report, he says:—

"The proposed canal will be filled with water, as free from sediment as the water in the open sea, on either side of the island. It is not a river in the rainy seasons,

bringing down immense quantities of silt, either to form shoals or to feed the surrounding coasts with deposit, to be driven in course of time into the canal mouth. On the contrary, there is not a stream of any size for a great distance on either side, unless it be the Vygay river, marked on the map as flowing into Palk's Bay, to the north of Paumben. From all I could learn, no changes of sufficient importance to be noticeable have taken place in the vicinity of the proposed canal within the present generation. On the whole, therefore, there appears to me to be good ground for hoping that the amount of dredging, for maintenance, will be very small. A little sand will be blown in from the banks, but even that may be reduced in quantity by encouraging the growth of grass and scrub bushes, which already grow pretty freely along the site of the canal. As regards the general direction of the wind, the course of the canal is tolerably favourable. During either monsoon, a vessel passing through will have the wind fore and aft."

Again he says, further on—

"Ramiseram, at present, is a barren island, not connected with Ceylon or India by road or rail; but should a ship canal be made through Ramiseram, it is rather remarkable to think that this barren island will be the only point in the peninsula of India, from Calcutta to Kurrachee (not excepting Bombay, in its present want of accommodation), where a large vessel will be able to land and discharge her cargo direct on to a quay without the intervention of cargo boats. I believe that this fact alone will, as labour becomes dearer, and time more valuable, attract a large proportion of the commerce of Southern India, and perhaps the north of Ceylon, to the island of Ramiseram, independent of the more immediate value of the canal, the shortening of the passage to and from India."

Respecting the proposal to cut the canal from Port Lorne through Ramnad Spit, Mr. Robertson reported as follows:—

"In the excavation of any ship canal through Tonitory Point, the probability is that a large amount of sandstone would be obtained."

And again—

"The land-cutting will be much more than in the Ramiseram Canal, both from length, and because, so far as the eye could judge, the level of the land above the sea is a little higher on the average. The expense will, therefore, be greater on this score, as well as from the fact that, from external examination, the probability of a quantity of rock is very great. The dredging may be a little less on the south side, but on the north side, the distance of the five-fathom line out at sea is greater than at the Ramiseram site."

Sir Wm. Denison evidently chose his position on account of the deep water being close to the north and south shores, and the northern entrance being sheltered by the headland of Paroovadum, ignoring the more elevated ground and the want of shelter at the southern entrance.

Mr. Robertson clearly chose his site on account of the small amount of cutting through Ramiseram, and the shelter afforded at southern entrance, ignoring the greater length and quantity of deepening both for north and south entrances, and the indirect and awkward nature of the southern approach to it by the only channel that can be economically deepened.

Mr. Stoddart was surveying for months on the spot from Port Lorne to Manaar, and from long personal observation of effects of waves, tides, and currents in the Gulf of Manaar and Palk's Straits, arrived at the conclusion that the site nearly midway between Mr. Robertson's and Sir Wm. Denison's, has more advantages of shelter than the former at the northern entrance, and as much at the southern, with less deepening at both entrances, although entailing slightly deeper cutting through the island, and has less cutting and more deepening than the latter, with infinitely better shelter at the southern entrance; requiring no artificial breakwater, and nearly as well protected at the northern entrance by the headland Paroovadum already referred to. Too much deepening in the open sea is expensive at the outset, and afterwards costly to maintain, from the liability to silting up arising from cross currents, and must, therefore, be avoided as much as possible, if it can be done, still retaining the natural shelter the formation affords at both ends of the canal. Mr. Stoddart's position combines so many advantages over all other designs that, after full consideration of the merits of the various proposals, I have arrived at the conclusion that the middle position between Mr. Robertson's and Sir W. Denison's is, upon the whole, the most suitable for the purpose in view. I am quite convinced it will prove economical in construction and maintenance. The indecision on the part of the Indian Government, after so much investigation, and so many valuable reports respecting the most eligible site for this canal, should now give place to a determination to execute the work as speedily as possible, while labour and materials of every description are so cheap and abundant as at present.

The entire work can most certainly be completed in four years, including the erection of lighthouses, fixing of buoys and beacons, and requisite light-ships over the patches north-west of Jaffna Peninsula. Bearing in mind the vast importance of this route for the development and convenience of Indian and Ceylon trade, it is well worthy of being made perfectly safe throughout for shipping at any hour, and in any weather. The work would prove a great blessing in relieving the superabundant labour market of Southern India in a way just suited to it, and on completion of the canal, docks, and railway, constant employment would be afforded to a great number of the native population in perpetuity.

There are many works in India of far less importance than this canal even locally, which have been carried out at very considerable expense, without one quarter the investigation and labour expended upon this design. Delay up to the present time has resulted in the one great benefit of fixing indubitably the best and cheapest position for the proposed canal which can possibly be obtained; but there can be no further excuse alleged, now that the matter is made clear, for delay in inaugurating the undertaking. Facilities bestowed for foreign and interportal trade will greatly increase the general revenue of India, and at the same time be self-supporting, from the reasonable port dues which would be willingly paid, more especially when the native cargo boat can be dispensed with, and shipping can lie alongside wharves or quay walls. It seems almost incredible, but it is an unquestionable fact, that from 3s. to 5s. per ton must be added to freights on account of discharging by cargo boats, around the coasts of India and Ceylon, to which must be added losses of no inconsiderable amount

in transit between the ship and the shore. With the convenience of wharf loading and unloading, these heavy charges would be reduced to about 6d. per ton on all merchandise. The total charge now entailed on Indian merchandise under this head must amount to a very considerable sum, and the loss of time arising through it to shippers and shipping, generally, must also be great. From calculations entered into, it is not too much to say that loading and unloading at wharves instead of by cargo boats would save India £1,250,000 annually in hard cash, without reckoning losses between the shipping and the shore. Under the improved state of affairs, the boatmen would find other occupations on shore of a kind to suit them, or in fishing. The case of Madras is so bad that it has actually been proposed to make Colombo, on the completion of its breakwater, and Ramiseram, on the completion of its canal, the Port of Madras, goods and passengers being sent overland to their destination. This was considered a satisfactory reason why the Union Railway should be made over Adam's-bridge, joining the Indian system to that of Ceylon. It is very doubtful whether the breakwater constructing at Madras will be a permanent success, but even if they are, goods and passengers must still be landed in boats. Many people would feel extremely glad at the prospect of being able to shorten the voyage to Madras, and avoid the landing there by landing at Colombo or Ramiseram, and performing the remainder of their journey overland in 24 hours in a comfortable saloon carriage, to having two days' more voyaging, and the final prospect of disembarking in a drenching surf at Madras, or perhaps undergo the risk of being taken on to Calcutta, no landing at Madras being possible. Seeing that the union railway between India and Ceylon must be made some day, it is a pity that the Southern Indian line should be constructed on the narrow gauge, and the Ceylon, as well as Indian main lines, on the broad gauge. The break of gauge will be found a great hindrance to the due development and economical working of traffic between India and Ceylon, as, for instance, at Lahore, on the Peshawur branch, as ill-advised a decision on so important a part of our frontier as could well be imagined, as has already been amply verified since the commencement of the Afghan war.

If the Indian Government refuse to undertake this highly reproductive work and splendid investment of capital, which cannot be said of much of India's liabilities, beyond the main line railways, because they are hampered with a debt of about £130,000,000 (of which £25,000,000 are for productive public works), entailing an annual charge of £5,000,000, private enterprise will, no doubt, gladly step in, and relieve them of a duty that they consider too burdensome to fulfil, notwithstanding the immense benefits which will certainly accrue to the coasting and foreign trade of India, together (including British Burmah) amounting to £162,000,000 and 20,000,000 tons annually. Properly executed, it requires no guarantee, as it is as certain to pay a very handsome profit on the outlay as that it will be used instead of the present route round the south of Ceylon, on account of the saving in distance, in time, and in expense, besides the much greater safety in stormy weather all the year round.

Trade.

The Calcutta trade through the Suez Canal has increased to £22,000,0000 annually, and goes on steadily increasing. The trade of Madras is about £10,000,000, and that of Burmah about £6,000,000. Making ample allowance for the trade with China and Japan as well as Australia, which in the case of Madras and Burmah would probably amount to no more than £5,000,000, and assuming that the annually increasing coast trade of India and Ceylon was equal to the same amount only, but it is believed to be much more, we have a total foreign trade of £38,000,000 that would use the Ramiseram Canal. The whole of this trade would be conducted in greater safety and more expeditiously, all the year round, than at present. Taking the saving that would be effected in time of transit, wear and tear, and greater security and freedom from shipwrecks common round the south of Ceylon, at only one per cent. for everything on the value of ships and goods, it would, at very low calculation, amount to £440,000 annually, or about the cost of constructing the canal. I am perfectly satisfied in my own mind that the annual saving to be effected through the opening of this canal is greatly underestimated, but that is only one half the boon that will be conferred upon India and Ceylon by its construction. Both countries will have another harbour in railway communication with them, developing greatly the local trade of the adjoining districts.

Southern India absolutely requires, without delay, a convenient port at all seasons of the year, and no better site than this could be selected. Quays and docks can be constructed at an economical rate by widening the canal, and with greater facilities than at Port Lorne, and infinitely better sheltered, in a position suitable to Ceylon as well as India. This element in the question should not be forgotten. Nearly all the Indian ports labour under the enormous disadvantage of having no docks or quay walls, rendering loading and unloading by boats compulsory. The docks and quays in the Ramiseram Canal would afford unusual facilities for loading and unloading, and being put in railway communication with India and Ceylon, a great trade would spring up at it, ensuring the prosperity of railway, docks, and canal. As a port for southern Madras, perfectly landlocked and sheltered, accessible from north or south in any weather, it would become a great favourite, and would influence trade hundreds of miles away from it.

Dry docks, where refitting and repairing could be carried out, would eventually be established, thus enabling ships disabled to dispense with the voyage to Bombay for that purpose. Indeed, it may be seen that, owing to the enormous trade that would spring up in the locality, facilities for repairs would be necessary, and the nature of the ground would render the construction of repairing and graving docks easy. There being no more than an average tide of three feet, gates for wet docks would be unnecessary, and would be required for repairing docks only. The canal must be made first, the railway, wet docks with quays, and warehouses, and graving docks, would soon follow, when the immense facilities and convenience of the situation for Northern Ceylon and Southern India were fully realised.

The Indian foreign trade employs about 13,000 ships entered and cleared, with a total tonage of about 6,000,000. Interportal or coast trade employs a vast number of vessels of all kinds, and the number is annually increasing. The tonnage is computed, according to entry and clearance, at no less than 20,000,000.

It requires only 1,000,000 tons at 6d. per ton to pay £25,000 per annum, and 2,000,000 might safely be reckoned upon, being a very low estimate, to pass through the canal. Allowing 50 per cent. for working expenses and maintenance, the balance would pay 7 per cent. upon the moderate outlay contemplated.

Madras and Calcutta alone have now a tonnage of 2½ millions of foreign trade, the greater portion of which would pass through the Ramiseram Canal, in addition to which there would be the enormously developed interportal or coast trade, now being carried on to a limited extent through the Paumben Passage. It is firmly believed that steam shipping would supplant many of the immense number of native craft engaged in the Indian coast trade, and our shipbuilders would, therefore, reap a rich harvest through the opening of this ship canal, superseding sailing vessels to a certain extent around the Indian coast.

The average number of ships passed through the Suez Canal during the last three years was 1,571, with a gross tonnage upon which dues were paid of about 3,200,000, which does not by any means represent actual freight-carrying power of every kind, which would probably be nearer 5,000,000 tons. It is not too much to say that more than two-thirds of this tonnage goes to and from Colombo, Madras, Calcutta, Chittagong. Akyab, Rangoon, and Moulmein, and would therefore pass through the Ramiseram Ship Canal on economical considerations, being the shortest and safest route to and from these ports.

In lecturing upon this subject before the Royal Colonial Institute in June, 1878, I maintained that, on account of the enormous prospective traffic through the canal, it should be made, throughout its length, of rather more than three miles between 30 feet soundings, of sufficient width for vessels to pass each other in any portion of it without stopping; but I have since come to the conclusion that the cutting through the island may be limited to the average breadth at base of the Suez Canal, with a siding in the middle for vessels to pass each other, where the docks would eventually be made. This will reduce the cost of the undertaking very materially, without interfering with the passage of the shipping to any appreciable extent, or limiting the trade, as the usual time from either entrance to the siding will be about ten minutes for a steamer, or sailing ship towed by a tug.

The canal is straight across Ramiseram, and there will be nothing to interrupt a clear view from the Gulf of Manaar to Palks Straits. The average depth of cutting above low water mark, is 12 feet; and from the bottom of the canal to the general ground surface, 38 feet, through sand and soft sandstone. The whole of the excavation can be done by hand labour, without blasting, and by dredging, at a very economical rate. The deepening from low water mark to the extreme limit from the shore of 30 feet of water, will be through sand, soft sandstone, and mud. There is nothing to prevent it being done expeditiously and economically, by using the patent Hopper dredger of Messrs. W. Simons and Co., Renfrew, in conjunction with stationary dredgers and screw hopper barges. They would be at work all the year round, except in very wet and stormy weather, as the anchorage is quite sheltered from south-west and north-east monsoons for one mile, from either entrance to the canal. The deepening beyond that distance, on the south side, is very trifling, and could be done in those months of the year that are comparatively free from the monsoon. It must, of course, be remembered that this work will in no manner be permitted to interfere with the existing coast trade through the Paumben Channel, although the deepening crosses the entrance to it; yet the width is so great, that only a small portion of the channel will be occupied at one time, thus leaving the existing trade entire freedom of passage.

In a very instructive paper on "The Colonial and Indian Trade of England, contrasted with her Foreign Trade," read by Dr. Forbes Watson before the Colonial Institute, in February, 1878, occur the following terse and opportune remarks:—

"The financial history of the last four years supplies the most striking testimony of the superiority which the investments made in the Colonies and India possess over those made in foreign countries. As illustrating this subject, I cannot refrain from referring to an instructive account which appeared a few days ago in one of the daily papers, describing the mode of procedure countenanced by judicial decisions, in which American railway speculators may, in the most legal manner, deprive English bondholders of every fraction of their invested capital, without leaving them the smallest means of redress.

"We may sum up the advantages of this investment market within our possessions in the statement that it is characterised by the same qualities of steadiness and security which in a previous portion of the paper have been pointed out as the characteristics of the colonial and Indian market for our manufactures. An additional inducement for directing the current of investment rather to our own dependencies than to foreign countries, may be found in the circumstance that every such investment, independently of the direct money return it will bring, will likewise contribute to develop their resources and to extend their trade with us, while, in the case of a foreign country, our capital may often only serve to make that country independent of our markets."

The Ceylon Government, with important railways and the great Colombo breakwater now in hand, together to cost about three millions sterling, do not at present feel apparently any interest in the prospects of the proposed Ramiseram Ship Canal, being so much occupied with these larger schemes for the improvement of internal and external communications more intimately connected with the Port of Colombo and its prosperity. The matter is one clearly for the Indian Government to prosecute vigorously to a conclusion, after having demonstrated incontestably to them the best site for the canal, and the inestimable benefits it would confer on Indian commerce at a comparatively small outlay. As there need not be any doubt about the work proving a highly remunerative one, the money required to complete the undertaking can be borrowed or raised on

debenture bonds bearing interest at four per cent., with the Indian guarantee. These bonds could be all redeemed within 20 years, leaving the undertaking perfectly free, without having cost the Indian Treasury a rupee. Should, however, the authorities refuse to undertake this reproductive project for the improvement of the navigation and creation of a secure port between Ceylon and India, there ought to be no great difficulty in forming a company to carry out what would not only prove very profitable to them, but exceedingly beneficial to Indian trade for all time. As Dr. Forbes Watson wisely suggests in his admirable remarks quoted to you, we should expend our surplus resources in developing our own colonies, where we are nearly always sure of a handsome return, and of increased trade in addition, fighting shy of the seductive seven per cent. of needy foreign countries, and prospective repudiation after a few years payment of interest grudgingly wrung from them.

DISCUSSION.

Mr. Andrew Cassels said he had been extremely interested in the paper, and no doubt there would be great advantages in such a canal. The only difficulty in his mind was, whether during very stormy weather, the access to either end would not be dangerous and difficult. There were, however, several matters in the paper which he could not agree with. Mr. McBean seemed to bring a kind of indictment against the Indian Government for not doing more, but if we would only consider the various works that were pressed on that Government, it would be seen that they did not deserve so much censure. Some great authorities called on them to spend 30 millions on irrigation works, others pressed the completion of railways, and others the expenditure of $2\frac{1}{2}$ millions on making a harbour. How was it all to be done? Thanks to successive famines and the depreciation of silver, the finances of India were thrown very much out of gear, and the money for all these undertakings could not be found; and when they came to the House of Commons for power to borrow money, they were met with the most determined opposition. Mr. McBean said that the harbour of Bombay stood in still greater need of improvements, but he considered it one of the finest in the world, and a magnificent dock was being constructed which would be open now in a very few mouths. He also seemed to ignore what had been done at Madras. There was no breakwater there, but a harbour was being constructed, by which passengers and merchandise would be landed in perfectly smooth water if Mr. Parkes' plan proved successful. He feared that Mr. McBean was a little over sanguine with regard to the trade of India, and some of his figures rather startled him; probably the wish was father to the thought. The main point he wished to insist upon was, however, that India was a poor country, and could not be expected to undertake all these magnificent public works of various kinds.

Mr. Simons (Renfrew), as the maker of the hopper dredger referred to in the paper, asked leave to give a few particulars with regard to it. His firm had constructed seven, which were now at work in different parts of the world. One in Australia had removed from the Adelaide bar 263,000 tons of material; the crew consisted of 14 hands, and the wages were £31 per week. A report from the engineer to the Adelaide Government showed that it did six times as much work as their old dredger with six attendant barges, and for one-fourth of the cost. There was also a great saving in the cost of sending out one complete vessel to such a distance, as compared with sending out a dredger and attendant barges.

Mr. B. Haughton, C.E., said the harbour accommodation on the Indian peninsula at present was very deficient; as had been stated, there were only three harbours of any importance on the coast line, Kurrachee, Bombay, and Calcutta. A very splendid harbour was being made at Madras, and Mr. Parkes was a gentleman who brought a great deal of talent to bear on the question, and the Duke of Buckingham had also taken a great deal of interest in it. At the present time, when there was such a craze for the making of canals, it was necessary not to be led away too much by the idea that wherever there was a narrow isthmus it must be crossed by a canal. In this case he feared the shortening of the route by 350 miles would scarcely warrant making a canal through the island of Ramiseram. It seemed to him that Mr. McBean placed more stress on the harbour to be made in connection with it than on the canal itself, but he thought the new harbour of Colombo would have quite as many advantages as the one proposed in connection with this canal. Having been through the Suez Canal at the time of the opening, he was much struck with the fact that it was necessary to make two large moles to protect the entrance, and it seemed to him it would be equally necessary in this case; but this did not seem to have been provided for in the estimate.

Mr. Carruthers said in a country like India, where there was so much to be done, the Government must always have a difficulty in deciding which was the best way to spend the little money it had. He could not agree that cutting a canal through this island was the best way of spending the small amount of money the Indian Government could spare. It was very true, unfortunately, that there were very few harbours, but all along the whole coast there were excellent means of landing by lighters. Mr. McBean estimated that this cost from 3s. to 5s. per ton. He thought that was rather high. But comparing it with land carriage for the 3s. it would cost you to land without the harbour, you could only carry the same goods eight or ten miles along a country road. In Madras they had carried on a very large business without any harbour at all, and now, when the railway was made and trade increased, the Government was making a fine harbour, which, he was glad to hear, would prove a success.

Mr. Cassels said that was considered doubtful.

Mr. Carruthers said that was his idea. He knew they had great trouble there from shifting sand beaches, and the same difficulty occured all along the coast. If this canal were made, with or without moles at each end, he feared there was a possibility of it silting up, and without such a mole it seemed preposterous to talk of digging a ditch in the open sea, and expecting captains to bring their ships there, unless a proper protection were afforded at the mouth. The great difference in the various estimates no doubt arose from this cause.

Mr. McBean said the breakwater would shelter the canal proposed by Sir William Denison, but on Mr. Stoddart's plan it would be sheltered by the island.

Mr. Carruthers doubted if the island would afford sufficient protection. The great point seemed to be that this would give a harbour where ships could lie and unload without having recourse to lighters; but, still, imagine a Madras merchant, wanting to get his goods to Madras, and landing them away down there, and carrying them overland by railway, when he could land them at Madras at an expenditure of 3s. to 5s. per ton. It would cost 30s. to 40s. to carry them over that distance by rail. As a canal, it would no doubt be useful, if the Government had the money to spend; but they had not, and, even if they had, it would be better

expended in remitting the heavy taxation which now pressed so heavily on the population.

Mr. Carlisle said he was well acquainted with the harbour of Madras, and, whichever way the monsoon was, the lee side of the pier silted up; and he believed, whatever distance they put it out, eventually it would be the same. At Jersey, a pier had been built some two miles long, and at that time there were 30 ft. of water, but now there were only 6 ft.; and the same result would occur at Madras. With regard to landing goods at Madras, he might mention that sometimes the Government found it cheaper to take heavy material to Bombay and land it there, because it was a sheer impossibility to land it at Madras when the surf set in there by the north-east monsoons. In Madras roads they charged about three times as much to take out a heavy piece of machinery as they would to take it to Calcutta. Under these circumstances, would it not pay the Government to have a safe harbour constructed as described in the paper? The canal was a necessity, and it must be made, and if the Government did not find the money, a private company would. Some years ago he was at a meeting here, when it was proposed if the Government did not take this matter up a company should be formed, and that with a very small percentage it would pay its own expenses. It was then estimated to cost some £100,000, and the Duke of Argyll, who was then in power, said the matter would be taken in hand, but like so many other things connected with India, it was deferred As to Bombay being a fine port, you could not land a single thing there without a boat; Calcutta was the only place where any improvement had been made, and that was done by private enterprise; if the rail had not been open to Calcutta there would be no wharfs there yet. One of the Peninsula and Oriental boats would save £100 worth of coal if this canal were made, and that alone would pay the canal dues. The current in Ceylon was not so great, and he did not think there would be any danger from silting up. With regard to the Suez Canal, there was not a pier at each end, but only at the north end to protect it from the silting from the Nile; the hotel there, which was once 10 yards from the beach, was now a mile and a half off. When that canal was made, it was said that the sand would fill it up, and that the Mediterranean side would fill up, but the truth was that the Mediterranean side hardly required dredging at all, not more than an ordinary pond, and the dredgers were seldom going in the canal. As long as they built a pier out on the Mediterranean side, silting would take place, and it would be just the same if it were carried out for five miles.

Mr. Haughton said there were two moles at the north end of the canal, and there were none at the Red Sea end because they were not required, the canal delivering itself there into a narrow bay. But in an open space like this, with this sea running at each side, he thought it would be almost necessary to have moles at each end.

Mr. A. Rogers sympathised with what Mr. Cassels had said about the unceasing calls made on the Indian Government for projects of all kinds. Mr. McBean had enlarged on the advantage accruing from making this canal, and he quite agreed with him that there was great want of harbour accommodation on the coast of India. No doubt this would be an advantageous place, from the figures he had given, and he had little doubt that the undertaking would pay. If other people were only convinced of this the matter would be soon taken up by a private company. The Indian Government had so many calls upon them, that it was unreasonable to expect them to take up an untried scheme of this kind. One advantage with regard to this canal was rather fanciful, namely, that passengers to Madras would have the great advantage of landing there to go up by rail, but they could already do that by landing at Bombay and going across, or by landing at Beypore, and negotiations were now taking place with the Portuguese Government for making a railway from Goa to join the Indian system.

The Chairman said it had given him great pleasure to be present and hear this able paper read. The subject was not new to him, for he was in India on a shooting expedition in 1842, and took a passage across from Colombo to Masulipatam on his way to the Neilgherry-hills, he then stopped at Paumben, and walked over the whole place. He was much struck with the place, and being a sea-faring man, he sounded with bamboos, and found that a canal could, as he thought, be constructed across the island exactly in the place where Mr. Stoddart had now designed it. There was no danger in Palk's Bay, for it never blew a gale of wind there. He could speak with certainty on this, for he had considerable property in the Peninsula of Jaffna, and they had kept a weather record there for the last 30 years, and never but once was there a gale of wind enough to blow a cocoanut off a tree; it was rather a lacustrine sea, there was no drift and no depth. On the south-west the monsoon did not blow home; it was stopped by the islands which lined the coast of Tinnevelly, and as the monsoon blew up the Gulf of Manaar it encountered the influence of the hot plains of the Carnatic, and the wind took off and did not blow home; it never blew more than a single-reef topsail breeze at any time. All the discussion about horns, jetties, and moles, he looked upon as being very much exaggerated; in fact, he believed, from the nature of the soil the canal could be constructed for a very cheap rate indeed. It would require to be lighted with a first-class light at Point Pedro, in Ceylon, a floating light at a certain other point, and another light at the southward entrance. Without wishing to reflect on his old masters, the East India Company, he did think they might have done a little more for lighthouses than they had. On one of the islands they wanted a first-class light. Then on Cape Comorin you required another, so that you might run up to the mouth of the Paumben Channel with nothing more than a small floating harbour light to take you in. In 1862 he obtained a committee of the House of Commons to investigate this subject, and witnesses were examined, including General Simms, General Monteith, Sir Arthur Cotton, and many others, and it was recommended that Palk's Straits and the Paumben Channel should be closely examined, with a view to undertaking these works. But it never entered his head, although he had done what he could to forward this work, that the Government of Madras or Ceylon should be called upon to do it. It was strictly an imperial question affecting the trade and commerce of the whole world. Under that idea he always supposed it was the duty of the Government of India to endeavour to obtain, by means of a private company, the means which it was not convenient for themselves to lay out. A large harbour work, however, had been undertaken, and he was rather inclined to agree with the gentleman who had spoken somewhat strongly against it. His acquaintance with Madras was of long standing, having been employed as a junior officer in landing ordnance there in 1818. It was quite true that if you carried a groyne out in the Madras roads the beach went out with it, and that was the case all along the coast. To return to the plan before the meeting, one little anecdote would illustrate its great advantage. About the year 1850 or 1855, there were two ships sent out to sail for Tutieorin. One of them was able to lighten herself to 11 feet, which was the depth in the Paumben Channel, but the other, which drew 12 or 13 feet, was obliged to go round Ceylon. They were both laden with cotton. The first one went through the Paumben Channel, and as she was sailing out of the harbour six weeks afterwards, the other vessel came in, having been obliged to

go down across the line and get into the south-east trade winds to come round. That was the inconvenience of sailing ships, but now that the amount of steam trade which resorted to the Bay of Bengal was increasing every year, this canal would be of immense advantage. There were parliamentary returns of this trade brought up to two years ago, and, as far as he could make out, a few years ago there were about 220 voyages of steamers cleared out from London, and, taking £100 as the saving in expense for 750 miles of steam mileage on each round voyage, that would amount to £220,000. The trade had much increased since then, and it was his belief that for £400,000 the whole thing could be done; and he did not see why the trade of Great Britain should be taxed to that amount when it would be possible, by such a small outlay, to save that distance. The navigation round Ceylon was not only dangerous, but expensive, owing to the great wear and tear. Under these circumstances, he thought it would be a proper thing for the Government of India to have the thing set at rest. All these various routes had been closely examined, and the whole materials were now ready for proceeding at once. No doubt the Government had many calls upon them, but some schemes had more common sense in them than others, and there had been mistakes made in harbour works which would have more than covered the expense of this canal. He believed that with the friable soil, consisting of disintegrated coral rock and blue clay, the greater part of the work could be done by the dredger, and if it had been taken in hand at the time of the famine, a great deal of it might have been done very cheaply. The island of Ramiseram was in Indian terrritory, and, consequently, in the hands of the Indian Government. He concluded by proposing a vote of thanks to Mr. McBean for his able paper, which was carried unanimously, and the meeting adjourned.

SEVENTEENTH ORDINARY MEETING.

Wednesday, April 2nd, 1879; Andrew Cassels, Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Goslin, S. B., The Crescent Foundry, Cripplegate, E.C.
Hellyer, S. Stevens, Torridge, St. John's-road, Brixton, S.W.
Jones, Alfred, 31, Eversfield-place, St. Leonards-on-Sea.
Lincoln, Dean of, 26, West Cromwell-road, S.W.
Moreland, John B., 4, The Paragon, Blackheath, S.E.
Parry, T. S., Castle Bar-hill, Ealing, W.
Purdey, James, 28, Devonshire-place, Portland-place, W.
Stevens, Henry, 22, Bedford-row, W.C.
Trower, Henry, 39, St. Mary-at-Hill, E.C.
Tunbridge, William Thomas, London and North-Western Railway, Stafford.
Warner, Robert, The Crescent Foundry, Cripplegate, E.C.
Wilson, Richard, 53, Parliament-street, S.W.

The following candidates were balloted for and duly elected members of the Society:—

Bullivant, William Pelham, 72, Mark-lane, E.C.
Emery, Robert, Cobridge, Staffordshire.
Ferreira, Eduardo de Moraes Gomes, C.E., 15, Bedford-place, Russell-square, W.C.
Greenhill, Matthew Cranswick, South Hawes, Southport.
Pescott, Benjamin H., Southamptou-hall Literary Institute, 269, Southampton-street, Peckham, S.E.
Stevenson, James, F.R.S., West Nile-street, Glasgow.

The paper read was—

SOME CAUSES OF THE PRESENT DEPRESSION IN TRADE.

By B. Francis Cobb, F.S.S.

In bringing to your notice a subject such as this, it must be borne in mind that the limited space of time available is utterly inadequate to the requirements necessary for its full and comprehensive investigation. It should, therefore, be understood that many circumstances and statistics bearing upon different points have been unavoidably omitted, others curtailed, and many of the minor causes not touched upon at all.

Foremost among the causes of the present depression must be admitted the great inflation of the early years of the present decade, and, although some thinking minds foresaw and spoke of the inevitable result, few cared, while all went happy as a marriage bell, to earn the title of croakers, by expressing their misgivings; and, while the prosperity of the country "advanced by leaps and bounds," until the reckless extravagance of living enabled the Excise to pay the Alabama Claims, he would have been a bold prophet who would have publicly foretold a reaction which, in its severity, would be proportionate to the extent of the inflation, and only to be dissipated by a renewed energy, the offspring of a probation of misery approaching in its character to a severe struggle for existence.

Contemporaneous with what may be called the natural reaction from the abuse of credit, extravagance, and thriftlessness, the race entered into by almost every civilised country to outrun the rest by the rapid development of all kinds of industries and enterprise, in most cases by means of borrowed capital, came certain other causes which served to increase the intensity of the depression, notably the unprecedented fluctuation in the value of silver, the unexpected depreciation of which went far beyond all previous experience. The causes of this depreciation are not difficult to trace. The demonetisation of silver in Germany set free a quantity of that metal, which was equal in the period 1872-7 to an additional production of £5,000,000 per annum. But the substitution of a gold for a silver currency by Germany would not have so greatly disturbed the equilibrium, had not the means adopted to carry through the measure aggravated the evil, and produced at times panic prices, such as are bred of ignorance and apprehension. We know now, that in the period 1872-7, the imports of silver from Germany exceeded £23,000,000, and, allowing only £7,000,000 to have been exported elsewhere, we have an aggregate of £30,000,000 in the six years, but we do not know what amount of silver Germany has still to sell, nor at what price she will dispose of it, nor when; and remembering that in 1877 she sent to this country £13,747,000, it is no wonder that when she is known to be operating, a semi-panic is the result. Had Germany taken all Europe into her confidence, she would have done better for herself, better for the world at large.

Notwithstanding the pressure of the German export, India would have absorbed, without very much difficulty, a large portion of the silver poured into the country, had not a new and unexpected

element made its appearance, in the shipments westwards of silver from the Nevada mines. During the last two years the export of bullion from San Francisco to British India, China, and Japan has been—

	Dollars.
1877	18,268,830
1878	11,860,920

From 1863 to 1870 the production of silver in California kept very closely to 16,000,000 dollars per annum. The following table gives the production since that time, in dollars :—

	Dollars.
1871	24,246,000
1872	27,549,000
1873	38,500,000
1874	40,250,000
1875	46,500,000
1876	48,000,000
1877	47,300,000
1878	42,945,000
Total production of silver only during the eight years ending 1878	315,290,000;

or, say, £65,000,000.

The continuous depreciation of this metal has been most disastrous to much of that great staple manufacture of this country, the cotton fabrics for the Indian and China markets, for while the consumer there might pay the same number of rupees or dollars as formerly, the merchant, when attempting to get his funds back again, was faced by a loss of 20 per cent. from the depreciation of his silver rupees or dollars. Naturally, he turned to any produce of the country as a means to an end, and thus, demoralising the natural course of trade, aggravated the evil by enhancing the value of produce. Instances were not uncommon where individuals in India, debarred from the natural channels of making remittances to this country, were necessitated to find themselves shippers of produce, amateur merchants, demoralisers of the markets at either end, and generally concluding their operations with a painful experience of the results brought about by a great depreciation of silver.

The result of all this has been that, for the purposes of exchanges, the value of the rupee has been 1s. 7d. instead of 2s., a depreciation of one-fifth, or 20 per cent. The value of Indian export produce has had a higher proportionate value than before, from the reasons I have already given, aided by the lowness of freights consequent on the depression of the shipping trade.

A recent writer gives the following estimates:—

	Present price. Rupees.	Former price. Rupees.	
Rice	$3\frac{1}{2}$ at 6	2 at $2\frac{1}{2}$	per maund.
Jute	$4\frac{1}{2}$ „ 5	2 „ $2\frac{1}{2}$	„
Linseed	$4\frac{3}{4}$ „ 5	3 „ $3\frac{1}{2}$	„

Had commerce been in a natural condition, the low value of the rupee would have been compensated for by an increased rupee price of the imports, but, unfortunately, at this time famines had caused a deep distress, and lessened to a considerable extent the purchasing power of the natives, while the depression of trade at home was forcing upon every available market more than its legitimate requirements, and that, in some instances, by means of a spurious credit and dishonest trading, such as we have recently seen exposed in the wretched history of the City of Glasgow Bank and its accessories.

Another prolific cause of individual suffering, causing depression in trade from lessened income and capital, has been the waste of the capital of this country in foreign loans. The following table, abstracted from the Report of the Royal Commission on the Stock Exchange, gives—

Loans in Total Default.

Loan Issued.		
1860-1873.	Turkey	£89,000,000
„ „	Peru	26,000,000
1860-1864.	Mexico	16,000,000
„ „	Venezuela	4,600,000
1867.	Honduras	3,500,000
1871.	Uruguay	2,300,000
1872-1874.	Paraguay	3,000,000
1872.	Bolivia	1,700,000
1871.	Costa Rica	3,400,000
1864.	Confederate States.	2,400,000
	Various	5,200,000
	Total	£157,100,000

In Partial Default.

Spain	£109,000,000
Egypt	45,600,000
Austria	6,900,000
Alabama	1,000,000
Columbia	1,500,000
Argentine	1,000,000
Portugal	8,700,000
Chili	700,000
Buenos Ayres	700,000
Total	£175,100,000

Here we have 157 millions in total default, and 175 in partial default, or, together, £332 millions, which have been wasted, inasmuch as it has served to spread dishonesty and corruption on the one hand, and misery and depression on the other.

The total amount of foreign loans placed in this country since 1860 is estimated to be not less than £495 millions, three-fourths of which may be said to have been wasted, and the other fourth to have benefited other countries. In these estimates, colonial loans are not taken into account; neither could colonial loans, if of a proper description and use, be said in any way to be a cause of a depression; on the contrary, they are a natural channel for the wealth of this country to flow into, and should assist commerce, in this country as well as in the colony itself.

I have mentioned the reckless extravagances of the earlier years of the present decade, and among these extravagances that which has more to answer for than any other, as being a cause of the present depression and distress, is the inordinate consumption of intoxicating liquors. A synopsis of the recent Excise returns, by Mr. Wm. Hoyle, of Claremont, are so valuable, that I make no apology for re-producing a considerable portion of his letter as it appeared in the *Times*:—

"The following table gives particulars of the various kinds of intoxicating liquors consumed, together with the money expended thereon. It also gives the consumption for 1877:—

	Gallons.	1878.	1877.
British spirits*	29,358,715, at 20s.=	£29,358,715	£29,888,176
Foreign spirits†	10,438,637, at 24s.=	12,636,364	12,742,277
Wine‡	16,272,295, at 18s.=	14,645,065	15,904,146

* See Trade and Navigation Returns, February 1879, page 72.
† Ditto ditto December, 1878, page 12.
‡ Ditto ditto December, 1878, page 14.

	Cwt.	Bushels of Malt.		
Beer—sugar used*	1,128,226 =	4,813,760		
Do.—malt used†	...	57,259,393		
		62,073,153		
	Gallons.			
Equal to	1,117,316,754, at 1s. 6d.	... 83,798,756	...	81,722,632
British wines, cider, &c., (estimated)	17,500,000, at 2s.	... 1,750,000	...	1,750,000
Total		£142,188,900	...	£142,007,231

"From these returns it will be seen that in 1878, with all the terrible depression which prevailed in trade, the money spent upon intoxicating liquors was £181,670 more than in 1877.

"During the last seven years the total expenditure upon intoxicating liquors in the United Kingdom has been £987,320,669."

Mr. Hoyle then compares the seven years ending 1863 with the seven years just ended as follows:—

Year.	£	Year.	£
1857	92,319,147	1872	131,601,402
1858	88,148,335	1873	140,014,712
1859	92,892,557	1874	141,342,997
1860	86,897,683	1875	142,867,669
1861	94,942,107	1876	147,288,760
1862	88,867,563	1877	142,007,231
1863	92,088,185	1878	142,188,900
	£636,155,577		£987,320,671

"From the above it will be seen that the increase in the expenditure upon intoxicating liquors during the seven years, ending 1878 as compared with the seven years ending 1863, was £351,165,094, being an increase of over 55 per cent.

"The population of the United Kingdom in 1863 was 29,433,918, and in 1878, 33,799,276, being an increase of less than 16 per cent. in population as compared with an increase of 55 per cent. in the consumption of drink.

"The entire value of all our exports for the four years ending 1878 was £815,000,000, being £171,000,000 less than the money which the nation spent on drink during the seven years just ended.

"If to the drink expenditure we add the indirect cost and losses resulting therefrom, it would increase the drink bill by at least £100,000,000 per annum, and it would show a national loss far exceeding the total of all our foreign trade.

"The enormous burden of the drink expenditure is one that in the face of the world's competition we cannot continue to carry, and especially as it is accompanied by a deterioration of the workman which makes the burden all the greater, and outside competition all the more possible.

"Every one who wishes to preserve our national *status* will be anxious to help all efforts for redeeming the country from the foul blot of intemperance, which paralyses its trade, corrupts its morals, and degrades its population to an extent which is beyond conception."

Another cause of the present depression may be found in the way other countries are taking raw materials that used to come to this country, and manufacturing them themselves. Take, for instance, the silk trade. Some years ago five-sixths of the raw silk exported from China found its way to this country; that is to say, that, taking the export at 60,000 bales, 50,000 bales, of an average value of £100 per bale, were landed here. It would appear, however, that this year, supposing the export to be 60,000 bales, only 20,000 will come to England, and 40,000 will go elsewhere; or, in other words, twice as many will go elsewhere as will come here. I need not point out to an audience of the Society of Arts how grave a matter for consideration this is, neither is it my province to-night to enter upon any suggestions by which this serious loss of industry, business, and income to the country might be arrested. My paper is limited to some of the more apparent causes of the present depression, but I should like to let you know the answer given to me by a silk manufacturer, in reply to a question as to why he continued using certain machinery which had been already superseded on the Continent. He said, "I know what you mean, and what you are driving at, but if I were to make the alterations you would suggest, I should set fast some thousands of pounds, and as soon as it was seen that I was making a better article than before, at a smaller cost, my hands would all go out on strike for an increase of wages."

* See Trade and Navigation Returns, February, 1879, page 71

† Ditto ditto February, 1879, page 71.

Now let us turn to the cotton industry.

The following statistics are taken from the annual statement of the American crop issued by the Brokers' Association. The figures relate to the present crop and those of the crop of 1859-60 as being the two largest ever grown, and nearly equal in size.

These figures show that whereas we have taken 632,700 bales less than we did out of the crop of 1859-60, our competitors in Europe and America have taken 787,961 bales more:—

Years.	Exported.		Taken by American Spinners.	Total Deliveries.	Crop.
	Great Britain.	Foreign Ports.			
1859-60	2,669,432	1,104,741	964,628	4,738,881	4,973,007
1877-78	2,036,732	1,309,908	1,549,422	4,896,032	4,941,758
Increase ...	...	235,567	584,794	155,181	...
Decrease ...	632,700	...	...	...	31,249

I would now draw your attention to some careful reports made for the *Economist* on the exhibits of various countries which have contributed examples of cotton manufactures to the International Exhibition of 1878 of more than usual interest, as giving some idea of the progress made during the last 10 or 12 years.

"In the present Exhibition, the French have shown in a very decided manner the progress they have made in this useful and important branch of industry since 1867; and, bearing in mind that Mulhouse is not represented, as in all former exhibitions, the display is a very remarkable one. The progress in every phase of cotton manufacture, except perhaps in fine yarns and sewing-cottons is, however, undoubted. Plain sheetings and shirtings show better make and finish, and a nearer approach to the best English standard of these goods than heretofore. The fancy goods, quilts, damasks, &c., are in some respects equal to the best Manchester fabrics, and occasionally superior in design, and the printed goods, especially the madder prints, approach the old standard of Mulhouse, if, indeed, they do not come up to them. Certainly, in the matter of design they are everything that can be desired in such goods. One thing is clear—that so far as the display in this Exhibition is concerned, the French cotton trade has attained a position, as regards facilities of manufacture in relation to excellence, which, under extended means of production, will make it a very formidable

rival to those countries which have hitherto taken the lead, and especially to England, in fancy goods and madder prints.

"The principal advance made by the United States of America is in sewing-cottons, which approach nearer to the best English standard. The comparison is easier than in the instance of the French, because the 'make-up' is more like the English. In plain cotton goods the United States are on a par with England in the qualities exhibited.

"Russia exhibits a representative collection of cotton fabrics, plain cloths, twills, sateens, and damasks, the last-named being well designed. The yarns and water twist range from 16's to 100's of fair quality.

"The fine numbers, and the Turkey-red dyed yarns, show a very decided advance. In printed goods, too, the progress of Russia is very marked, alike in design, style, and finish, but some of the lower class of goods are very deficient in the latter quality. The fabrics, however, are sound and even, and when dyed the colours are good.

"Switzerland exhibits yarns more extensively than any other country, except, probably, France. The numbers run to 200's, and the quality is generally good. Some dyed yarns are particularly clear and bright. The result of an examination of these Swiss yarns suggests that in the numbers spun they appear to be in a position to supply not only their own wants, but those of other countries. The woven cotton and printed goods are all of average quality in every respect, and give evidence of ample sources of production.

"Sweden and Norway produced sparingly, but the quality is generally good. The dye and fancy cottons, twills, &c., exhibited by Sweden are highly creditable as regards quality and finish.

"Belgium shows very little progress. The goods exhibited are all of fair average quality and finish, and nothing more. In yarns there may be some advance, but not much.

"Spain and Portugal give very interesting, because very practical, illustrations of their products, as also the Netherlands. The best goods of the latter are tickings, and Turkey-red yarn. The Portuguese fabrics are all of good medium quality, but nothing more. The Spanish goods range over a much wider field. The damasks, quiltings, and prints are generally well designed and of excellent finish. The printing and dyeing are quite equal in quality to anything of the same kind produced in England, and in may points are superior as regards design. The whole exhibit is meant to prove that Spain can help herself in this direction.

"Austria does not show any very decided advance in cotton productions. The quilting and coloured damasks, and fancy towelling with woven and embroidered borders, are more fanciful than practical, and appear simply intended to meet a special home demand.

"In proportion to the extent of the English cotton industry England is only partially represented in the Exhibition. There can be no doubt about the sterling character of all the goods exhibited, and we may look in vain for any serious rivalry as regards these productions, either in quality, colour, or finish, whilst a very marked improvement is visible in the designs of the fancy fabrics—damasks, prints, quiltings. &c. In sewing cottons England still holds her own. Of course, in the midst of universal depression, the English cotton trade must suffer, but she has suffered also from the distrust as to the real quality of cotton fabrics, engendered by the system of over-dressing, introduced during and after the cessation of the 'cotton famine.' Merchants demanded cheap goods, and quality was a secondary consideration. A profit must be made at any cost of reputation. The manufacturer had to meet the demand for a cotton fabric, say at sixpence, the price of which, if unadulterated, would be eightpence. China clay was the rubbish worked into the yarn as a dressing, which gave weight and apparent substance to the fabric. The first visit of the fabric to the wash-tub exposed the cheat. Can anyone wonder that a trade carried on in this way ended in distrust, depression, and finally stagnation."

May we not consider the adulteration of manufactured goods as one of the proximate causes of depression in that particular manufacture, be it silk or cotton? I think so, and that it fairly comes within the scope of this paper, and so I proceed to call your attention to the recent case of Provand v. Langton, in which the defendant's analytical chemist stated that the analysis of the shirtings, representing 27,500 pieces, was—

		Per Cent.
Fibre		53
China clay		26
Starchy matter		12
Fatty matter		$2\frac{1}{2}$
Magnesium	Chlorides	2
Zinc	Chlorides	$1\frac{1}{2}$
Calcium	Chlorides	$\frac{1}{2}$
Moisture, &c.		$2\frac{1}{2}$
		100

Well might the Lord Chief Baron speak of the goods as being about half cotton and half adulteration.

Now let us hear what Mr. C. Cross, of Pendleton, has to say on this matter. I give you his own words:—

"When mill owners receive no return for their capital, and workmen's wages are, step after step, dwindling down to nobody knows where, it is surely time to examine into the real cause which has brought us into such a slough of despond. The bulk of the yarn spun in the Oldham district are for weaving eastern 'shirtings,' and more bales of cotton are imported to produce that one article than any other two articles together. Our calico piece was at one time a circulating medium in every clime; we have now, however, so debased our calico currency, that it rots in transit, ruins every man who touches it, and so disgusts the ultimate wearer that he seems determined to have no more at any price.

"Having, myself, experience in a bit of cloth, I have been curious to compare the wooden nutmegs of the present day with splendid spices of the past. I, therefore, append certain calculations to explain my argument.

(A.) Taking a 39-inch shirting, $37\frac{1}{2}$ yards, 16 by 15, and $8\frac{1}{4}$ lbs., as the best standard reckoning 119 hanks of warp, and 112 hanks of weft, its original construction, with 10 per cent. of size, were under 30s. counts of yarn both ways that combination made a serviceable article which would weave well, wear well, and sell well.

Calculation A.

119 hanks at $29\frac{1}{2}$s. = 4·03 warp.
10 % of size = ·403

4·433
112 hanks at $29\frac{1}{2}$s. = 3·817 weft.

lbs. 8·25

"The next step was 32s. warp, with 33 per cent. of size, and 34s. weft, that was a variation in the wrong direction, but our trade would have been better to-day if it had never been exceeded.

Calculation B.

119 hanks at 32s. = 3·72 warp.
33 % of size = 1·23

4·95
112 hanks at 34s. = 3·3 weft.

lbs. 8·25

"Not content with that, we take another false step (see calculation C); with 32s. warp and 61 per cent. of size and 50s. weft, we have the same weight of piece, but there is 1·34 lbs. of excess of warp over the weft, and also 2·06 lbs. of excess of size, equal to 3·40 lbs. thrown away, as that piece contains no more weaving endurance than if it had been made of 50s. warp and 50s. weft, weighing 4·85 lbs. altogether (see D).

Calculation C.

119 hanks at 32s. = 3·72 warp.
61 % of size = 2·29

6·01
112 hanks at 50s. = 2·24 weft.

lbs. 8·25

Weight they ought to be made and sold for.

Calculation D.

Way this ought to be made if 50s. weft is put in.

lbs. 2·38 = 50s. warp.
·23 = 10 % of size.

2·61
2·24 = 50s. weft.

lbs. 4·86

Weights thrown away.

Calculation E.

Leaving excess of
Warp .... = lbs. 1·34
Size .... = lbs. 2·06

lbs. 3·40

"Not content with that, we take another false step (see calculation F); with 32s. warp, and 68 per cent. of size, and 56s. weft, we have the same weight of piece, but there is 1·6 lbs. of excess of warp over the weft, and also 2·32 lbs. of excess of size, equal to 3·92 lbs. thrown away, as that piece contains no more wearing endurance than if it had been made of 56s. warp and 56s. weft, weighing 4·33 lbs. altogether (see G), yet it sells for $8\frac{1}{4}$ lb. fabric.

Calculation F.

119 hanks at 32s. = 3·72 warp.
68 % of size = 2·53

6·25
112 hanks at 56s. = 2·00 weft.

lbs. 8·25

Calculation G.

Way this ought to be made if 56s. weft is put in.

lbs. 2·12 = 56s. warp.
·21 = 10 % of size.

2·33
2·00 = 56s. weft.

lbs. 4·33

Calculation H.

Leaving excess of
Warp .... = lbs. 1·6
Size .... = lbs. 2·32

lbs. 3·92

"Not yet content, we take another false step (see Calculation I); with 32s. warp and 72 per cent. of size, and 60s. weft, we have the same weight of piece, but there is 1·72 lbs. of excess of warp over the weft, and also 2·47 lbs. of excess of size, equal to 4·19 thrown away (just half the piece), and that piece contains not one iota more wearing endurance than if made of 60s. warp and 60s. weft, weighing 4·06 lbs. altogether (see J), although it sells as $8\frac{1}{4}$ lbs. fabric.

Calculation I.

119 hanks at 32s. = 3·72 warp.
72 % of size = 2·67

6·39
112 hands at 60s. = 1·86 weft.

lbs. 8·25

Calculation J.

Way this ought to be made if 60s. weft is put in.

lbs. 2·00 = 60s. warp.
·20 = 10 % of size.

2·20
1·86 = 60s. weft.

lbs. 4·06

Calculation K.

Leaving excess of
Warp .... = lbs. 1·72
Size .... = lbs. 2·47

lbs. 4·19

Note.—D is as good as C.
G — F.
J — I.

"If that is not the way to ruin a trade, pray which is the way to do so? To recapitulate:—

With 50s. weft 3·40 lb. is thrown away, leaving only 4·85 lb. of useful material in piece.
With 56s. weft 3·92 lb. is thrown away, leaving only 4·33 lb. of useful material in piece.
With 60s. weft 4·19 lb. is thrown away, leaving only 4·06 lb. of useful material in piece.
From $\frac{3}{8}$ to $\frac{1}{2}$ of the weight of the piece, is useless or spoiled.

"It would be interesting to ascertain the exact moral difference between a Pendleton grocer slyly selling me butter 'short weight' of eight ounces to the pound, because I had no scales at hand, and Messrs. Blackburn and Burnley slyly selling India 'short quality' calico, containing only about half its well-known original wearing properties, as shown in calculations I, J, and K. If all calicoes were stamped with the makers' names, with plain figures of breadth, length, weight, reed and pick, counts of warp and weft, and quantity of size they would look quite as handsome as the ugly griffins and hieroglyphics now disfiguring the wrong end of stuffed goods. The fear, however, is that whatever we do now can never recall the century of prosperity and monopoly which we have enjoyed, especially in a cloth requiring such little skill as the weaving of a mere 'calico piece.'"

Reference has been made to workmen going on strike, and while the subject of strikes is one which is more fitted for an entire paper than for such brief notice as time will permit of in this, yet it is obviously so important a factor that it would be improper not to mention it as one of the causes of the present depression of trade. The action of a strike is to resolve itself into the most absolute waste that can be connected with commerce and commercial enterprise. Among the actions within the control of men, only war can be more wasteful

in its effects. It is so everywhere, although it is only of recent years that the United States has undergone this baneful experience. Speaking of the great railway strike there, Mr. Plunkett, Secretary of Legation at Washington, reports that the centres of the strike were West Virginia, Pennsylvania, and Maryland; they extended thence to Ohio, Indiana, Illinois, Michigan, Iowa, and Missouri, north to New York, last to New Jersey. On the 12 larger lines the loss is put down at five and a half millions sterling for property destroyed, cattle and other live stock killed, for none of which the companies can claim on the State or County Governments. But the Governments will have to pay as large a sum for loss of property by riots arising out of the strikes. During the three weeks from 16th July to 4th August, 1877, the cost to the country directly is reckoned at £13,000,000 sterling in positive loss in property and business.

One of the most evil effects engendered by strikes is the ill-blood and bad feeling which remains, even after work has been resumed; and when strikes are from the direct action of trades unions, as they generally are in this country, the difficulty is only laid by for a time, to be resumed on the first available opportunity. The arbitrary action of many of these trades unions, and the submissive manner in which their orders are received and obeyed, is one of the most surprising things of the present time. A man gives up his liberty, and places himself unreservedly at the disposal of irresponsible despots, whose first act is to reduce him to the level of the meanest and least valuable artisan of his class. The union shipwrights who caulk ships' decks at Palmer's shipbuilding yards at Jarrow are a good instance. The union men recently struck against a man named Burdon, who by diligence managed to distance his fellow workmen in the amount of caulking he did in a day, and was remonstrated with by them. As he refused to shorten the length of his work, the men took umbrage, held a meeting, and the union passed a resolution that he should not be allowed to work at the trade for three years. As the masters however would not discharge the man Burdon, the men were ordered out on strike.

Another instance of the arbitrary rule of the unions was in the case of a builder building some houses in the suburbs of London, on the clay, where he had reason to fear the effects of damp. He invented a very ingenious large hollow brick, and commenced building his houses with them. It soon occurred to the workmen that they were building these houses very quickly, and they reported the matter to the union, who sent special officers to investigate, on whose report orders were sent not to use any more of those bricks. With great difficulty, and by paying fees to the union and extra wages, the builder at length obtained permission to complete the house nearly finished.

It is well, when we can, to see ourselves as others see us. The correspondent of a New York monthly publication writes from this country as follows:—"There can be no doubt that the original and principal cause of the depression in all the branches of industry in England is directly traceable to the arbitrary regulations of trade unions, which have acquired a much more perfect system of organisation here than anywhere else." He traces their development in recent years, and states the general results, and adds "a yet more serious cause serves to enhance the cost of production, and is one result of the arbitrary regulations of the trade unions. I refer to a system of virtually handicapping labour by a rule which does not allow a unionist to work with a will. However much skill he may may possess, or however willing he may be to work rapidly, he is forbidden to accomplish more than an average amount of work in the usual time, because it might derogate from the interest of his less skilful or less willing brother unionist. The same regulation exists in all trades where it is at all applicable." The writer further expresses his opinion that "the English seem to be in such a perfect state of lethargy that they cannot, or will not, realise that their manufacturing monopoly is fast vanishing from them, and that the nation which is acquiring it shows a very fair prospect of retaining it."

Of course we may say that this last is an American way of putting it for publication in a New York journal, but there is the fact that the Americans are manufacturing goods which they previously purchased in this country, they are bearding the unionistic terrorism of Sheffield on its own ground, and they have entered the lists as our competitors in almost every foreign market in the world.

The Mayor of Sheffield, in a speech made only in the middle of last month, stated that in his opinion the distress of that town was owing in a great measure to the trade unions of Sheffield. It was within his knowledge that a very large contract had been offered to an extensive firm of manufacturers. The firm had taken two similar contracts previously, and on both those contracts they had lost money. When the third was offered them they called their workmen together and told them that if they would accept 10 per cent. reduction the firm would take the contract, which would give full employment to the men for 20 weeks. The workmen considered the matter, and, after some discussion, agreed to do the work, but the leaders of the union now stepped in, and distinctly told them they were not to accept the 10 per cent. reduction. The consequence was that the order is now being executed in Belgium, and the working classes in Sheffield are suffering to that extent.

Machines for the manufacture of carriage springs were sent over to this country, but were tabooed by the union, with the result that the machines were sent back to Belgium, and carriage springs are now being made with them there, and imported into this country. It is known also that "grinders" who had been working longer than the trade unions thought good, had on the following day found that their tools had been removed, because of the action taken by the men in working longer hours than the union permitted. It was a matter of very great regret to the Mayor of Sheffield, to find the trade unions doing so very much to prevent the expansion of the trade of Sheffield.

At a meeting of the Cleveland Institution of Civil Engineers, held last December, Mr. J. Head, one of the leading manufacturers of Middlesboro', moved and supported by an excellent speech the following resolutions:—

1. "That whilst recognising the important bearing

which the Imperial policy of Government must ever have upon trade, this meeting is of opinion that the present depression is mainly due to the operation of natural laws, which would have produced similar effects whatever the political conditions."

2. "That, considering the prevalence of extravagance and thriftlessness among producers of all grades in 1870 and the following years, and the enormous waste of time which took place through strikes and restrictions of unions, it is not surprising that the spirit of commercial enterprise should have become well-nigh extinct."

3. "That the only wise course for producers—whether employers or employed—now to adopt is to cease craving for higher prices, and to unite in cutting down cost of production, and adapting ideas and habits to the existing state of things."

4. "That the nine hours' movement, although nominally a success, was in reality, from the first, a great economic failure; that is, contrary to the true interests of the workmen themselves. That the present scarcity of employment is largely due to its operation, and that it ought to be abolished without delay."

I wish to draw your attention to these resolutions, although the third may be foreign to the subject of this paper—which, I must remind you, deals only with causes, not cures—but time will not permit of any comments upon them to-night.

Another cause of the depression of prices, and consequent depression of trade, will, I believe, be found in the diminished production of gold, concomitant with an increased demand for that metal.

The estimated production of gold in the years 1852 to 1873, in quinquennial periods, was as follows:—

	Total Production. £.		Annual Average. £.
1852-56....	149,655,000	......	29,933,000
1857-61....	123,165,000	......	24,633,000
1862-66....	129,800,000	......	24,700,000
1867-71....	108,765,000	......	21,753,000
1871-75....	76,800,000	......	19,200,000

The difference of an annual yield of from 25 to 30 millions between 1852 and 1861, and an annual yield of less than 20 millions at the present time, is obvious. One of the effects of the great gold discoveries was to create new markets for gold itself. Under its bi-metallic *régime* France replaced an enormous stock of silver by gold, and, becoming a gold-using country, absorbed the new supplies to an enormous extent. India, again, absorbed an immense sum, especially during the years of the cotton famine, when her credit abroad was so suddenly and so enormously augmented.

The effect of the adoption of a gold standard in Germany, as well as in some other European countries of minor importance, has been, as we have clearly seen, to depreciate the value of silver, measured by a gold standard, in an extraordinary manner. Large masses of silver have been demonetised and thrown upon the market. But, on the other hand, large masses of gold have been required to take their place, while, as has been shown, the supply has actually been diminishing. We have the authority of Mr. Ernest Seyd for estimating the amount of gold in circulation in Germany prior to 1871 at £30,000,000.

New German gold money coined to date ..	£83,000,000
Old German gold currency in 1871	30,000,000
Minimum increase in seven years ..	£53,000,000

Of this amount, about four-fifths has been forwarded direct from England to Germany.

The preparations made by the United States for the resumption of specie payments on the 1st of January last, have also absorbed a large amount of gold. The sums obtained for this purpose are:—

Gold coin and bullion in United States Treasury in 1878	£28,500,000
Gold coin and bullion in United States Treasury in 1876	12,000,000
Increase in two years	£16,500,000

These two requirements have absorbed £70,000,000 of gold in the past seven years—say, £10,000,000 a-year—or decidedly more than half of the world's production during this period. Currency reforms in the Scandinavian Kingdoms and in other countries have likewise absorbed further exceptional amounts, and after making the usual deductions for the arts and jewellery purposes, it is probable that the balance of new gold left available for the maintenance of existing gold currencies has, during the past seven years, been reduced to about one-third what it was in the previous decade. At the same time, all the principal banks in Europe have shown more and more eagerness to store gold in preference to silver.

Until 1866 it might be said the market for gold was so affected by extraordinary demands that the full effect of the new supplies on gold-using countries alone was never fully tested; but it is obvious that the diminished supply can not now meet the extraordinary demands which were met by the supply of the earlier years. Not only do the figures show an actual falling-off of supply, but there is a probability of the supply being obtained at a greatly increased cost of production. The 19 millions now produced are obtained with more effort than the 30 millions 20 years ago.

Deeper mining, more costly machinery, and the exhaustion of alluvial deposits mean that the increased capital required to be sunk, and consequent enhanced cost of raising the gold, may still further limit future production.

Another cause of the depression, a cause which is silently but nevertheless certainly producing its effect, is the way in which the electric telegraph is annihilating the merchant. By the merchant, I mean that class who used of old to be denominated "the merchant princes of England."

Let me illustrate what I wish to convey, by the change that is now rapidly taking place in the silk trade of China, and the sugar trade of the West Indies, and I select these merely as illustrations, and not at all as being exceptional. Formerly a house in Shanghai required to keep up a large staff of assistants; silk was bought as it came down from the interior, it was shipped home, and on arriving here was held for a market. Sometimes the silk was bought on account of Manchester firms who had consigned cotton goods to the Shanghai house, and the silk formed the return shipment carrying the proceeds of the cotton fabrics sent out. Commissions and sundry charges on the silk (including 1 per cent. for inspecting) amounted to about 5 per cent. A manufacturer, if he wanted 50 bales of silk, came up to London, went the

round of the warehouses and silk brokers, and having found what he thought would supply his wants, bought the parcel through a broker at the usual prompt.

Now, if the manufacturer knows his business, he will apply to an agent for a special parcel of silk, who will arrange with an Indian bank to cable a credit, with the order, to Shanghai, to enable the agent's inspector there to buy the silk, and ship it to this country. The Bank finds the money, receiving the drafts and shipping documents. It arrives at Southampton, goes direct to the mill, and the whole charge for the work done is 1 per cent. It is impossible for the merchant to compete here, for his silk would go to the bonded warehouses, and incur warehouse rent, working and sampling, and other charges, besides being sold through a broker, who would charge his commission. In Shanghai he would have to keep up his establishment, or pay commissions to another firm to do the work.

The other representative article I have selected is West Indian sugar. Formerly the planters in Cuba consigned some hundreds of cargoes every year to this country; they came to merchants here who made advances, and held the sugars until the market suited them to sell, and a great deal of this sugar was reshipped to its ultimate destination. Now, the merchants either acts as a banker, or he has retired; for the sugar is, so to speak, sold before it is bought, if, for speculation, the bill of lading may pass through many hands, but in the end the sugar arrives at Glasgow or at its ultimate destination, and goes from the ship into the melting pot. The consumers order in both cases is cabled out to the producer, and the merchant is shut out. The effect of the telegraph has been to bring the consumer into direct communication with the producer, to the exclusion of the merchant.

So with our staple exports; it will no longer do for the Manchester manufacturer to make and ship his goods to a market, he must sell his goods before he makes them, and supply only the indents of the native Chinese dealer and those things only which he requires.

But I am straying from the subject of my paper, which is to point out causes of the depression only, and while I should have liked that more time had been available for the investigation of so important a subject, I must conclude now with the hope that, before this Session closes, some more able hand than mine may be induced to give us a paper upon the best means to be adopted to secure to this country a return of that prosperity which, for the present, appears to have left us.

DISCUSSION.

Mr. Hale said one of the causes of the depression which had not been alluded to was the failure of the harvests for several years, amounting, he believed, to £80,000,000. Many of the things Mr. Cobb had alluded to were of great moment, but the state of Europe for the last three or four years had had a great deal to do with the depression, which was very great in other countries as well as our own. The shorter hours of work had, no doubt, something to do with it. He was at a meeting not long ago, where a man had the effrontery to suggest that, if all men did their fair share of work, no one need work more than an hour and a half a day. With reference to the decrease of exports, he believed it was rather the value than the quantity which had fallen off. He was glad that the adulteration of cotton goods had been noticed, which he considered a crime and disgrace to the country, and that an Act ought to be passed to check adulteration in manufactures as well as in food.

Mr. Stephen Bourne, after bearing testimony to the value of the paper, said he thought the influence of Indian exchanges had been vastly over-estimated, because there was no absolute loss, what was lost in one quarter being gained in another. If the rupee had not deteriorated in value in India, the Viceroy said the prices of goods had not increased, and the Indian Government endorsed the same opinion. There must be a gain on the importation of goods, because, were no other causes in existence, the wheat brought here would fetch as many pounds as before, and they could be converted into a larger number of rupees to be exported into India. If, on the other hand, the rupees had been reduced in value, the producing manufacturer got more for his produce than formerly, and was, therefore, in a better position to meet the taxes levied upon him, the nominal amount of which might be increased. Then, with reference to goods sent from here, if the rupee was reduced in value with regard to the purchase of home produce, the exporter must receive in the same coin as before, and if he converted it into produce, the gain in the one case would meet the loss in the other. India was a larger exporting than importing country, and therefore she must gain on what she sent here. No doubt the Indian Government was seriously embarrassed because it had to collect its taxation in rupees, which were depreciated, and to make its payments in gold, but the circle being completed, the loss at the one point was compensated by the gain at the other. With reference to foreign loans, there was a general misconception in attaching too much loss to this country on their account. A very large amount of them never went out of the country—probably not half. The loss to those who invested in them was of course serious, but the manufacturers benefited to a large extent, because the money was expended in goods, and this to a great extent raised wages, and tended to inflation of trade, which had helped to bring about the present stagnation. He believed that the factitious prosperity partly produced by these loans was a far greater evil than the absolute loss of money sent abroad. Again, with reference to trade unions, no doubt their operations in many cases were injurious, but he was inclined to agree with Mr. Brassey, that the power of trade unions arose from the competition among the masters for the employment of labourers. When the disposition to invest in foreign loans ceased, everybody thought of rushing into bricks and mortar, and that they would be putting their money safe. Immense building operations were gone into, which raised wages to an extravagant extent. The same thing occurred in the iron trade and in Lancashire. There could be no doubt that Mr. Cobb had hit one of the greatest blots in our social condition when he spoke of the enormous amount expended on drink. From calculations he had recently made, he had arrived at the conclusion that, taking the great industries of coal, cotton, and iron, it could be proved that the cost of these articles was increased 10 per cent. by the amount of drink consumed by the people employed in producing them, and the various channels through which they passed. This was a considerable bonus to be divided between the labourer and the capitalist, and he was quite sure that, until these drinking habits were reformed, we should see nothing in the way of prosperity returning to us. He believed that such a reformation would take place, because the reduced wages would not allow the operatives to consume so much. This was not yet apparent, because, of course, when men were out of work they wanted to drink more, but that state of things could not continue. This, how-

ever, was only one form of a great evil all round, not affecting the labouring population alone. All classes of society had been spending too much, and we had amongst us too great a number of non-producers. England was in the position that she did not produce the food she needed, probably not more than one-half; the other half had to be imported from abroad. It mattered not whether we employed labour in the direct raising of produce from the soil, or the indirect way of raising something which other nations would take in exchange for food, but the extravagance of our population, the large profits which our capitalists looked for, and the extravagant way in which they expended them, the large wages which the operatives required, and expended foolishly, had so far raised the cost of manufactures, while at the same time, adulteration had so far depreciated their quality, that our goods were now at a discount. The world refused to take them at the prices we formerly received, and hence the great depression. Although it came from a high authority (Mr. Giffen) that the decrease in exports was in price, and not quantity, some statistics which he had laid before the Statistical Society the previous evening, showed that there had been a considerable diminution in quantity as well as in price. Comparing 1872 with 1878, he found in the latter year a diminution of £62,000,000, £13,000,000 of which was due to diminution of quantity, and £49,000,000 to diminution of price. But it must be borne in mind that not much more than half of the diminution in value was real, because we had received a large proportion in the cost of raw material. The conclusion he came to was that, roughly, the loss was about half due to quantity and half to value. This was a serious matter, and even in the case of value, he could see no cause for congratulation, because it only meant that, in order to sell our goods, we had to submit to prices which were not remunerative. It afforded no hope of increase of trade until we could reduce the price by lowering the cost of labour and the expenditure of capitalists, and then we might be able to compete with the foreigners. A great deal was heard now about "reciprocity," "protection," and such like crazes, but such remedies would be absolutely futile. We were now absolutely dependent for our food upon the maintenance of our markets abroad, and if we could not compete with foreign manufacturers our trade was utterly gone. If we needed "protection" at home to enable us to compete here, we must have it abroad also. We must either manufacture our goods at such a price as would enable us to find a market abroad, or cease to be a manufacturing nation. He believed we should have to cease, to a considerable extent, because we had hitherto had a monopoly of capital, skill, and natural advantages. We had imparted our skill to others, our capital was ready to flow to other nations, and the natural advantages we possessed had been discovered elsewhere. Therefore, he believed, we could not demand so much of the manufactures of the world as before, but there was no occasion for despondency, because it should lead us to open up new markets. We had our vast colonies in which to find a home for a large proportion of our labouring population, and every family which settled there became consumers of our manufactures. Looking to the condition of the world, to our over-crowded state here, and to the large countries under our control, he believed it was in the order of Providence that we should disperse more, like Abraham and Lot, when they found the land too strait for them. We should embrace the opportunity of drawing the distant portions of our dominions closer together, and a large portion of our over-crowded population there, so as to increase the number of food producers abroad, who would be at the same time consumers of our own manufactures, and when that were done the depression so much mourned would cease to exist.

Mr. Wm. Botly said the agricultural side of the question seemed to have been omitted, though it was of considerable importance. This was not the first time of depression we had had, for he remembered similar times as far back as 1825 and 1826; in one year 115 banks stopped, producing far greater distress than the failure of the Glasgow bank last year. One of the ablest papers on the subject of the remedies for this depression was that read by Mr. Chadwick, M.P., at the meeting of the Social Science Association, at Cheltenham. We imported one half of our food supplies, and at the present time, as was lately stated in the House of Lords by the Marquis of Huntley, there were hundreds of farms thrown on the hands of the landlords, in consequence of the agricultural depression, and the failure of our food supplies. He believed the great remedy for that would be security of tenure and compensation for unexhausted improvements. If the farmer had these, there was no doubt that in many cases the produce of the land might be doubled.

Mr. Cornelius Walford said he must confess to a little disappointment at the way in which the subject had been treated, many of the remarks being trite, and applicable to the whole mercantile world as well as to England. He agreed with Mr. Bourne that the currency question had been made far too much of with regard to the depression of trade, and it only led people's minds from the true causes. The part which the metallic currency played in the commercial transaction was very small, probably three or four parts in a thousand, and, therefore, that question might be safely left to adjust itself. The real causes of the present depression of trade must be looked for here, and nowhere else. It had been clear long ago to those who thought on the subject, that strikes and their attendant circumstances, and also adulteration and fraudulent trade, would do for this country what they had done. He held in his hand a little book, written more than 200 years ago, and quoted by Adam Smith, in which the following passage occurred:—"It is in vain to expect a greater revenue of our wares than their condition will afford, but rather it concerns us to apply our endeavours to the times with care and diligence, to help ourselves the best we may by making our cloth and other manufactures without deceit, which will increase their estimation and use."* There was a prediction of what would happen and what had happened. We had gone on striving, not to excel in our manufactures, but to undersell the world by dishonest practice, and in the result we had cut to pieces the very trade by which we throve. Other nations, too, had done the same, and actually put English marks on their own fraudulent goods, and thus still lowered our reputation. Those who had visited the great exhibitions of Vienna and Philadelphia must have seen that we were being driven out of the market, and so we must be if working men were able to conduct strikes and to dictate the hours they would work. Every day lost drove away trade which could never be recovered under any circumstances, because the working men who competed with us abroad were better educated, more frugal, more temperate, and, consequently, more physically capable than our own. It was interesting to see what had happened in other countries, where trade had declined; and he would first take Genoa. At one time she occupied a foremost position in commerce, but, for reasons which he would not stay to go into, the trade almost entirely left her; though, very recently, it had, to some extent, returned. But wealth and prosperity did not leave Genoa. Her people became frugal —they lent out money at interest, and so their wealth increased. Holland, again, once occupied the foremost position in the mercantile world; but her trade gradually declined. Her wealth, how-

* England's Treasure by Forraign Trade; or, the Ballance of our Forraign Trade is the Rule of our Treasure. Written by Thomas Mun, of Lond, merchant, and now published for the common good by his son, John Mun, of Bearsted, in the County of Kent, Esquire. London, 1669 (third edition; first edition, 1661).

ever, had not, and she was now as rich as ever. If this had happened in other countries, we need not despair if some of our commerce passed away. We had coal and iron which would not pass away, and therefore we were better able to meet untoward circumstances than those countries he had spoken of. When the working classes awoke to the fact that our trade was passing away, and would do so unless they reformed, he was sure there would be an improvement, and in the end the present period of depression might prove really a benefit.

Mr. Neil said there was one matter which he thought had an important bearing on the question which had not been alluded to, viz., the recent famines in India. He agreed that the currency difficulty had been made too much of, but these famines had caused a depletion which it would take a long time to recover, and during that time the native population could not take so much of our goods. Another important factor in the result had been the extension of steam communication and telegraphs, one effect of which had been to reduce stocks. Formerly, when goods went round the Cape, there were two months' stocks always on the water, two months' more in course of preparation for shipment, and perhaps two months' more on hand in India; but now goods could be ordered by telegraph, and supplied in a month or so. Consequently, the old stocks had added to the glut from over-production, and helped still further to lower prices. He hoped that the period of manufacturing at a loss would soon come to an end, however, and possibly the recovery would be even more sudden than the fall. After all these dolorous predictions had been exhausted, he hoped some one would read a paper on the redeeming features of the case.

Mr. Christian Mast dissented from the parallel drawn by a previous speaker between the present state of things here and Genoa or Holland, and believed the causes of the present depression lay deeper than had been stated. At the close of the Franco-German war he pointed out how war and the uncertainty resulting from it, and want of credit, would act disastrously. The whole system of modern commerce rested mainly on credit, and when that was destroyed everything else suffered. Not long ago a friend of his came over here from the Cape, intending to purchase largely both here and in Sweden and Norway for importation, but when news came of the disturbances he changed his plans, because he saw, under present circumstances, it was no use to engage in speculations. He also differed from some remarks which had been made, tending to the conclusion that England alone could remedy the evils complained of, whereas the whole mercantile world formed one vast commonwealth, and the remedy must come from a moral improvement in the whole commercial community.

Lieut. Armit, R.N., wished to draw attention to two things of great importance which had not been referred to, the bounties given by foreign countries on exports, and the tariffs imposed by foreign countries on the imports of British goods. When a foreign Government imposed a duty on British goods, it was really demanding a certain portion of our labour, and if, by reducing wages, we were enabled to compete with the foreign manufacturer, the only result would be an increase in the tariff, so as still to exclude us from the market. The foreign bounties on the export of sugar had shut up nearly all the refineries in England. As understood, the fundamental principle of political economists, from Adam Smith to Hamilton, was that the interests of the consumer and the producer should be equally regarded, but the idea now seemed to be that the interest of the consumer should alone be regarded; and the consequence was that everybody considered cheapness only, and bought foreign goods to the exclusion of British. Mr. Bourne's figures showed that there was a decrease not only in the value but in the quantity of goods exported, but our colonies could supply us with food products far cheaper than the foreigner, and he would suggest that we should offer to our colonies that in a certain time. if they were ready and willing to supply us, we would put a duty on foreign grown produce.

Mr. W. P. B. Shepheard supplied the following figures in confirmation of the previous speaker's reference to the injurious action of foreign countries:—In the ten year period, 1852-61, which preceded foreign export bounties on beet sugar, of the average total imports of sugar the British tropics contributed over 60 per cent., the foreign tropics 30 per cent., and the Continent less than 10 per cent. Whereas, now, of the total imports, less than 30 per cent. comes from British tropical possessions, and over 35 per cent. from the Continent, the foreign tropics and other places contributing the remainder.

The Chairman said he had been much interested in the discussion, but with a good deal that had been said he could not agree. Mr. Bourne treated the exchange as a matter of no moment, saying that what one lost the other gained, but if he had as much to do with the revenues and finances of India as he had, he would probably tell a different tale. India had to send over so many millions to pay the interest on her debt, officers' pensions, interest on the railways, &c., and if every 2s. was only worth 1s. 7d., it must be evident what the loss was. Then think of officers in India with families at home, who could only send home what amounted to £400 a year instead of £500; this in many households made all the difference between comfort and distress. This was really a very serious matter, and the disturbance it caused in trade was very great. The trade to India had been completely paralysed in consequence; it was like a bird with one wing—the export wing was gone. No one could ship to India with the hope of making a profit, or even seeing his own money back again. How could the trade with India flourish while in one country business was carried on in gold, and in the other in silver; and there were constant fluctuations in the relative values of the two metals. No bankers would grant credit in silver-using countries at present, owing to the unsettled state of exchanges. The question was whether any great improvement could take place while Germany had still hoards of silver to put upon the market; and he understood that France also had large stores of silver in the bank. Several of his friends were of opinion that the only remedy was the adoption of bi-metallism, and he believed this opinion was gaining ground; but it would probably take a long while to convert John Bull to it. He viewed with a great deal of alarm the excess of imports over exports, which, during the last four years, amounted to 474 millions, and showed we were consuming our capital. He thought Mr. Cobb had laid too much stress on the appreciation of gold, and, to judge by an article in the *Pall Mall Gazette* of that evening, the falling off in the supply was not so great as had been represented. It said:—"The average annual production of gold in all quarters has been very little less than it was twenty years ago. Taking the three periods of five years each, 1857 to 1871, the total average annual production of gold was in millions sterling 25·4, 24·8, 24·6; and for the seven years 1873-8, it was 22·5—a diminution of 8 per cent., not a decrease likely to produce such a fall of 50 to 80 per cent. in general prices as we see around us." These figures did not agree at all with Mr. Cobb's. The present depression was, no doubt, in great measure, a reaction from the undue and fictitious prosperity of some years back. The prosperity of the working classes at that time, with high wages and short hours, had created habits of self-indulgence which were now bearing bitter fruit; the operatives must work longer and harder, and for less wages, if we were to retain anything like our old supremacy in manufactures. The effects of competition were really not yet understood by the labour

classes in this country, nor by a good many above them in the social scale. Being in Turin about a twelvemonth ago, he was much struck by its great appearance of prosperity, whereas some years ago it was a very sleepy kind of place. When he came home he mentioned the fact to a friend connected with Manchester, who told him that a Piedmontese friend of his had a mill in Turin, and that he had lately told him that Manchester men could not compete with him for the following reasons:—His men worked twelve hours a day instead of nine, and for lower wages, but then he lodged and fed them better than they could do it for themselves, and yet got a profit on it. He very much disliked the process of dressing calicoes, but did not think all the blame should be put on the shoulders of the manufacturers; the buyers were equally to blame. He was informed that very best and purest goods could always be had in Manchester, but the buyers preferred the cheaper kinds. Was Birmingham to blame for imitating gold, or Yorkshire for making shoddy? There were millions of people who could not afford pure gold and honest broadcloth, but were content with imitation jewellery and shoddy; and if everything of this kind were to be condemned, he did not know where you were to stop. No doubt the uncertainty of peace was a great cause of depression, but so long as foreign nations kept so many millions of men under arms, they must raise money to pay them, and this was a great cause of the high traffic. He was very sorry to see the same protective system being adopted in our colonies, Canada and Australia, for how could we expect foreign countries to believe in free trade when our own people deliberately adopted the opposite policy? No doubt the famines in India and China, and bad harvest at home, had had considerable influence, but he thought we must reform our ways at home if we were to recover our position. We could not devise heroic measures to restore trade, but, by adopting the old-fashioned virtues of sobriety, thrift, and industry, we might do a great deal, for these qualities, whether in an individual or a nation, would always meet with their reward. He concluded by proposing a vote of thanks to Mr. Cobb for his paper.

The vote of thanks was passed unanimously, and the meeting separated.

Mr. Cobb writes:—The late hour at which the discussion terminated, did not permit me to have the usual privilege of replying to the criticisms upon the different parts of my paper. As regards the agricultural interest, while it is suffering as much as any other, it is not a cause of the present depression, but the result of six bad harvests out of the last ten—added to the ill effects of the inflation prices of 1870-74, which told entirely against the farming interests without any corresponding benefits. The causes of the depression in the agricultural interest raised so many important questions, that I had no reserve but to omit the matter altogether, or make the paper unduly long. Mr. Bourne must accept my thanks for the valuable remarks he favoured us with, and when he gives us on his own authority the fact, that the cost of manufactures might be 10 per cent. less if we could only eliminate the element of alcoholic drinks, he tells us that which cannot be too widely known as a most important factor in restoring prosperity to the country, for many an industry at the present time could be saved by that 10 per cent. As regards Mr. Bourne's theory that the depreciation of the rupee should not make so much difference in the results to trade, seeing that the rupee is a mere instrument of exchange in the course of barter, which eventually brings back the first investment with an increase; it is quite true that when the circle is complete this is so, and, this, theoretically, is the course of business, but as a matter of fact we cannot get the circle complete at present, and this very thing is one of the causes of the depression, for, as the Chairman puts it, the Birmingham manufacturer shipping to India does not carry Indian produce back, but he does want the exchange bills drawn against produce by shippers, and these he cannot touch without a loss of 20 per cent. We must all thank Mr. Walford for his remarks, but while he speaks of remedies, and instances Genoa and Holland as examples of places after commerce has to some extent left them, he goes far beyond the scope of my paper. Mr. Neil draws attention to famines, but when Mr. Walford in his exhaustive papers dealt with this subject he required two full papers to compass this subject alone*. Mr. Neil, in pointing out how the telegraph reduces stocks and gives facilities for the consumers to supply them, readily confirms what I have already said about the annihilation of the merchant. As regards foreign countries giving bounties, this may be a cause of depression to the sugar refiner, but not to the community at large, and if foreign Governments think proper to supply sugar to the community generally by means of bounties paid for by the tax-payers of those countries, our manufacturers have still the cost of carriage, commissions, &c., to set off in their favour as against the bounties, while the general community benefits. The gentleman who raises this question may make up his mind that the discrimination duties in favour of our colonies, who seem to levy duties on our production when they can, are things of the past and gone for ever."

MISCELLANEOUS.

BOOK-POST RATES.

In the House of Commons on Monday last,

Dr. Playfair asked the Postmaster-General whether it was the case that for five years circulars printed by the papyrograph, the electric pen, and other mechanical devices for taking numerous impressions, had passed through the post as printed matter, at book-post rates, under the Treasury warrant of the 26th of September, 1870; whether a Post-office circular of February 11, 1879, had intimated that this privilege was to be withdrawn; and whether he would state to the House what compensating advantages to the public revenue were expected from this restriction, which was calculated to have a repressive influence on scientific invention.

Lord J. Manners—For somewhat less than four years past circulars copied by papyrograph, and for somewhat less than three years past circulars copied by the *facsimile* process, have been permitted to pass through the post as printed circulars. The same privilege, however, having from time to time been claimed for other copying processes, more or less like these on the one hand, and, on the other, more or less like ordinary writing, it was found unsafe to persevere in this course; and the law officers of the Crown, having been consulted upon the subject, advised that the Treasury warrant of the 26th of September, 1870, did not admit of any of these processes being regarded as printing, engraving, or lithographing. A notice was accordingly issued to the public, on the 25th of February, 1879, to the effect that only such circulars as may be printed with ordinary type, as in a book, or engraved, or lithographed, will hereafter be regarded as printed circulars. If circulars copied by the new processes were allowed to pass at the book rate, it would not be possible for the officers of the department to distinguish these from written circulars, nor, con-

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* In the paragraph beginning, "Had commerce been in a natural condition," I do draw attention to the effects of famine, and to some extent answer Mr. Bourne.

sequently, from ordinary written letters; so that, eventually, all letters placed in open wrappers would pass unchallenged at the book rate, to the serious detriment of the revenue.

CORRESPONDENCE.

THE TREATMENT OF IRON TO PREVENT CORROSION.

At the reading of my paper on Wednesday, 26th, Professor Abel called my attention to a process for oxidising iron by Captain Bourdon, and, reading from the "Revue d'Artillerie," stated that the gun barrels treated were coated by a loose film of red oxide. Now, red oxide of iron is not formed by dry air, or by dry steam, on hot iron, therefore, it is manifest that Captain Bourdon used moist air, air charged with water vapour, and hence the red oxide was formed before the water vapour became superheated steam, and that when it became so superheated it oxidised the iron by my process. This will be understood by those who have read my first paper, read on the 14th February, 1877.

I gave to the Government chemist of Jamaica, Mr. J. J. Bowrey, some time ago, specimens of iron treated by my process. I wrote to him, with a view to publishing in my last paper his report; the report did not arrive in time, I only got it on Saturday last, but it is, I think, important. I therefore ask you to allow me to give extracts from it:—

"Kingston, Jamaica,
"11th March, 1879.

"Dear Mr. Barff,—Your letter, dated January 18th, reached me too late for me to reply by last mail, and I fear this letter will get to you after and not before you read your paper. I arrived here early in May last, and since then the protected iron articles you gave me have been placed as follows:—The iron horse has stood indoor at my house, and is as perfect as ever, quite free from rust, and so are the screws and bolts; these latter have been exposed to the air of my balance-room. A pair of ordinary steel scissors, which have lain on the same shelf as the screws, but wrapped up in tissue paper are, I now find, a good deal rusted—they were bright when I brought them out, and have not been disturbed until yesterday. The gate handles and ventilating plate have been the whole time freely exposed to the sky and to the rain and sun. We have had rain at least one day out of two, I think, since May. The handles are free from rust excepting a few pin points. One handle I broke. Of course the broken surfaces have rusted freely. The plate shows a little more rust, but it is on upper sharp angles, where I suspect portions of the protecting film have been broken off by the plate being trodden on. In my balance-room I have a slab of polished cast-iron on which to cool crucibles, and it has to be polished once or twice a week to keep it free from rust; if exposed to the weather it would be covered with rust in a single rainy day.—I remain, yours very truly, James John Bowrey."

I have also this morning received from the City of Dublin Steam Packet Company the following comments on the report in your *Journal*:—

"City of Dublin Steam Packet Company,
"Liverpool, March 29th, 1879.

"Dear Sir,—In my report, as printed in the *Journal of the Society of Arts* of the 28th, which I presume you have sent me, there are the following errors, the first of which conveys no meaning. In the second and third lines the words "*when* it has been *treated* for this purpose," should be "*where* it has been *heated* for this purpose,"—that is, for joggling or setting,—and in the last line *clear* should be *clean*.

"I am now quite sure that the stains on the screwed stays were made by rust from the two pieces of iron which the foreman placed below them in the gutter. On cleaning the stays, the surface texture is quite perfect. I have replaced it in the same position with no iron near.

"I feel quite satisfied if the oxide coating can be imparted so as to adhere perfectly, the iron underneath will last for ever.

"I note from Professor Barff's paper that you can treat articles 6 ft. long in your present apparatus—Yours truly, John Nicholson, Engineer."

Frederick S. Barff.

CHAULMUGRA OIL.

The best reply I can make to the letter of Messrs. Corbyn, Stacey, and Co., in your issue of 14th March, 1879, is:—The late Mr. D. Hanbury, knowing the great value of chaulmugra, worked from the year 1862 until his death to introduce this oil.

Messrs. Bell and Co. have had the chaulmugra oil for many years, and it has appeared in the prescriptions of some of the profession most eminent in the treatment of skin diseases, but it never came into general use until a year and a half ago. I got a large supply of the pure oil, specially prepared for me in India, and introduced it into some of the London hospitals.

Messrs. Savory and Moore have also kept this oil for many years, and it is only lately that a large demand has sprung up for it.

These facts will, I think, confirm my statement when supporting Mr. Jackson, of Kew, in his remarks upon the difficulty of getting a fair trial for any new or foreign medicines in this country.

Although Messrs. Corbyn, Stacey, and Co. have published a second edition of a pamphlet on this oil, they were unable to furnish a single report from any English hospital, or any case of cure or relief in this country, and they had solely to rely on work done abroad for examples.

This did not satisfy me when I brought it to the notice of the profession in "New Commercial Plants," No. II., in which you will find accounts of cures effected in this country.

I am delighted to find these enterprising chemists pushing this oil into notice, as its value can hardly be over-estimated. Thomas Christy, F.L.S.

London, 31st March, 1879.

THE SMOKE NUISANCE.

In the *Journal*, 21st March, Mr. William Thomson, in his interesting paper on this subject, says (p. 366), in reference to the sewers being made the channels for the smoke from our chimneys, that nothing definite was brought forward on this idea until Mr. Peter Spence, F.C.S., in 1857, proposed, by means of the sewers and one gigantic chimney, to abolish the smoke nuisance of Manchester.

The fact, however, is that in May, 1854, I proposed the same idea in relation to the smoke nuisance of London, and though a friend requested Mr. Faraday to permit me to give a lecture on the subject at the Royal Institution, the answer I received from Mr. Faraday was that he was not certain that the smoke of London was not in some respects beneficial as an antidote to the evils of the putrefactive processes going on. I replied to this that these putrefactive processes were mainly operating in our sewers, and that these were the best possible channels to receive our smoke.

Instead of one gigantic chimney, I proposed for London 100 chimneys, of 14 feet diameter each.

Mr. George Deney, architect, in 1851, exhibited a plan at the Great Exhibition, depicting views analogous

to my own, and he and I, putting our heads together, "interviewed" several leading authoritities on the subject of drains, coal combustion, and heating apparatus.

Although this plan would doubtless be a grand solution of the smoke nuisance, and a magnificent method of deodorising London, yet I now fear it is too overwhelmingly big for adoption.

A humble modification of the plan, however, by which all the chimneys of one side of a continuous street could be concentrated into one terminal shaft, say 100 feet high, would not only much diminish the smoke nuisance, but act as an unfailing ventilator to all the houses so connected, and I have a paper containing this idea in the 1st vol. of the Social Science Transactions, 1857.

Latterly, I have thought, as I expressed in a letter, which recently appeared in the *Journal*, that the unusual use of gas as a heating and cooking power was the correct solution of the smoke nuisance.

If a gas ventilating stove could be so placed and used as to yield into the chamber the entire heat produced by the combustion of the gas, it would be quite as cheap a heating power as our present wasteful grates now are, and as there would be a great saving of labour, £40 a year might be saved in service and fuel for £20 more in cleanliness in an ordinary house of the upper class, while the social advantages in relation to cooking by ladies would be very great.

George Wyld, M.D.

OBITUARY.

Sir Walter C. Trevelyan, Bart. — Sir W. C. Trevelyan died on the 23rd of March, at the age of 82. Sir Walter was well known as an advocate of the temperance movement as regards both tobacco and drink. He was one of the oldest Fellows of the Geological Society, which he entered in 1817, and as a working geologist, when the science was in its infancy, he did much to advance it. His geological work chiefly related to Northumberland and the Faröe Islands, of which he was one of the first scientific explorers. He became a member of the Society of Arts in 1852. In 1857 he offered prizes, to the value of £70, for essays on "Marine Algæ as Food." The offer, however, did not produce any essays deserving the prize, and it was afterwards modified, a similar sum, afterwards increased to £100, being offered by Sir Walter for a process of preserving fresh meat. Many processes have been submitted, and tested, but, up to the present date, none has been brought forward of sufficient merit to justify the Committee in making the award. Sir Walter has also contributed occasionally to the Society's *Journal*.

GENERAL NOTES.

Australian Exhibition.—The works for the erection of the Sydney Exhibition are to be carried on by night by means of the electric light. On the 22nd of February, a Supply Bill was introduced, including £50,000 for the Exhibition, which was said, on the authority of the colonial architect, to be sufficient to defray the cost of the structure. The building will contain 340,000 square feet of space, or rather more than one-third that of the Crystal Palace in Hyde-park in 1851, and 90,000 more feet than the proposed Melbourne Exhibition building of 1880. It is to be cruciform, the nave extending to a length of 800 ft. and the transept 500 ft. There is to be a dome at the intersection of the nave and transepts, and a tower at each of the four extremities. It will be built principally of iron and glass, with some timber and brickwork in the basement.

Street Tramways.—Major-General Hutchinson, who has recently visited several towns in France and Germany, has given the Committee of the House of Lords the result of his observation on the use of steam power and compressed air on tramways on the Continent. He found that horses were frightened in many cases, and, as a general rule, the tramroad was in a bad state of repair. The authorities, however, in the different towns seemed to be in favour of them. He found in two towns that the police objected to them, on the ground that the speed with which they were driven interfered with the public locomotion.

British Association.—The Council of the British Association have given notice that it is intended to make a special effort to issue the Sheffield Report at an early date after the meeting. To enable this to be done, the Council request that all reports, and abstracts of all papers intended to be read in the sections, may be sent to the Assistant-Secretary not later than July 15, in order that, if approved of by the Organising Committees, they may be put in type before the meeting. Authors who comply with this request, and whose papers are accepted, will be furnished before the meeting with printed copies of their reports or abstracts. It has also been determined that no report, paper, or abstract can be inserted in the volume unless it is in the Assistant-Secretary's hands before the conclusion of the meeting.

Patents in France.—The number of Patents and Supmentary Patents granted in France from the 9th October, 1844 (the day on which the French Paten-law came into force) to the 1st January, 1878, has been altogether 158,282. They are distributed as follows :—

Year.	Patents.	Supplementary Patents.	Total.	Year.	Patents.	Supplementary Patents.	Total.
1844	625	97	722	1861	4,476	1,445	5,941
1845	2,110	556	2,666	1862	4,410	1,449	5,859
1846	2,088	662	2,750	1863	4,512	1,378	5,890
1847	2,150	787	2,937	1864	4,324	1,329	5,653
1848	853	338	1,191	1865	4,190	1,282	5,472
1849	1,477	476	1,953	1866	4,411	1,260	5,671
1850	1,687	585	2,272	1867	4,722	1,376	6,098
1851	1,836	626	2,462	1868	4,750	1,353	6,103
1852	2,469	810	3,279	1869	4,579	1,327	5,906
1853	3,111	954	4,065	1870	3,029	821	3,850
1854	3,492	1,071	4,563	1871	2,325	457	2,782
1855	4,056	1,342	5,398	1872	3,934	941	4,875
1856	4,403	1,358	5,761	1873	4,007	1,067	5,074
1857	4,586	1,524	6,110	1874	4,571	1,175	5,746
1858	4,400	1,428	5,828	1875	4,663	1,344	6,007
1859	4,039	1,400	5,439	1876	5,389	1,347	6,736
1860	4,606	1,516	6,122	1877	5,610	1,491	7,101

A New Instrument for the Mineral Analyst.—At a recent meeting of the Philadelphia Academy of Natural Sciences, Professor Koenig, of the University of Pennsylvania, exhibited what he calls a chromometer (or colour-measurer), a new instrument he has designed for making exquisitely delicate determinations of the presence of certain metals in ores. It is based on the optical fact that complementary colours will extinguish each other if mixed in proper proportions; *e.g.*, if to a green solution a red solution be added in suitable proportion, the liquid will become colourless. Professor Koenig has applied this principle to the colours which certain metals, as iron, manganese, copper, &c., produce when fused with borax, the only chemical used in this method of analysis. He prepares such glasses or beads containing known quantities of a metal in one hundred parts, and observes how thick a glass of the complementary colour must be to produce extinction. This chromometer is furnished with a glass wedge of a green or red colour, cut at an angle of about one degree. By moving this wedge before the glass bead, with the help of a suitable rack movement, a scale is moved at the same time, and when the point of extinction of colour is arrived at, the reading of the scale refers to a table showing the percentage of metal contained in the examined substance. By this method of analysis a correct determination of manganese in iron ore can it is said, be made in 15 minutes, which is not more tan one-third of time required by the usual methods of analysis.

NOTICES.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

April 23.—"English Fresh-water Fisheries." By J. Willis-Bund, Esq., Chairman of the Severn Fishery Board. Francis T. Buckland, Esq., M.A., H.M. Inspector of Salmon Fisheries, will preside.

April 30.—Renewed Discussion on Mr. John Holloway's paper (read February 12) on "A New Process in Metallurgy." Prof. H. E. Roscoe, F.R.S., will preside.

African Section.

Tuesday Evenings, at Eight o'clock.

April 29.—1. "Light Railways for Opening-up a Trade with Central Africa," by John B. Fell, Esq.; and, 2. "The Advantage of Railway Communication in Africa, as compared with any other Mode of Transport," by J. Conyers Morrell, Esq. Captain Sir Henry Tyler will preside.

May 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

Chemical Section.

Thursday Evenings, at Eight o'clock.

May 8.—"The History of Alizarine and Allied Colouring Matters, and their production from Coal Tar." By W. H. Perkin, Esq., F.R.S.

May 15.—Continuation of Mr. Perkin's paper.

Indian Section.

Friday Evenings, at Eight o'clock.

May 2.—"The Wild Silks of India, especially Tussah." By Thomas Wardle, Esq.

Cantor Lectures.

Third Course, by W. H. Preece, Esq., on "Recent Advances in Telegraphy."

Lecture I.—April 21.

Definitions of telegraphy and electricity. Electrical effects. Sources of electricity. Economical distribution of electric currents.

Lecture II.—April 28.

The transference of electricity. Wires. Insulators. Supports. Gutta-percha, india-rubber. Underground wires and cables.

Lecture III.—May 5.

Simple telegraphy. Visual and aural signals. Telephones. Telegraphic writing.

Lecture IV.—May 12.

Duplex, quadruplex, multiplex, and harmonic telegraphy.

Lecture V.—May 19.

Automatic and fast-speed telegraphy.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon.....Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Prof. Wrighton, "The Law of Distress for Rent, as it Affects the Farmer."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Society of Engineers, 6, Westminster-chambers, 7½ p.m. Mr. Charles E. Hall, "Modern Machinery for Preparing Macadam."

Medical, 11, Chandos-street, W., 8.30 p.m.

Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. 1. Mr. T. K. Callard, "Does the Contemporaneity of Man with the Extinct Mammalia, as shown by recent Cavern Exploration, prove the Antiquity of Man?" 2. Paper by Professor Lee.

Social Science Association, 1, Adam-street, Adelphi, W.C., 8 p.m. Mr. John Hullah, "Musical Instruction in Elementary Schools."

Tues.....Central Chamber of Commerce (at the House of the Society of Arts), 11 a.m.

Royal Horticultural, South Kensington, S.W., 1 p.m.

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Discussion on "The Electric Light for Lighthouses."

Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Mr. W. D. Bowles, "Exhibition of Antiquities from the United States of Colombia." 2. Prof. W. H. Flower, "The Mummy of a Papuan from Darnley Island." 3. Mr. M. J. Walhouse, "Rag-bushes and Kindred Observances." 4. Mr. F. G. Hilton Price, "Trellech."

Wed....Geological, Burlington-house, W., 8 p.m. 1. Prof. E. Hull, "The Geological Age of the Rocks forming the Southern Highlands of Ireland, generally known as 'The Dingle Beds' and 'Glen-garriff Grits and Shales.'" 2. Mr. W. J. Sollas, "The Silurian District of Rhymney and Pen-y-lan, Cardiff." 3. Mr. W. J. Sollas, "Some Three-toed Footprints from the Triassic Conglomerate of South Wales." 4. Mr. J. Arthur Phillips, "A Contribution to the History of Mineral Veins."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m.

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Astronomical, Burlington-house, W., 8 p.m. 1. Rev. W. H. Dollinger, "The Thermal Death-point of Known Monad Germs in Fluid." 2. Mr. R. B. Tolles, "An Illuminating Traverse-lens."

Society of Telegraph Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. 1. Adjourned Discussion on Mr. James Sivewright's paper, "South African Telegraphs." 2. Discussion on Professor Hughes' paper, "Experimental Researches into Means of Preventing Induction upon Lateral Wires." 3. Mr. W. H. Preece, "The Effects of Induction between Wire and Wire, with reference to the Electric Light."

Thurs...Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.

Royal Historical, 11, Chandos-street, W., 8 p.m. 1. Dr. Zerffi, "The Historical Development of Idealism and Realism. IV.—Modern Period: Descartes, Spinoza, John Locke." 2. Mr. Walter Hamilton, "Inquiry into the Origin of the Office of Poet Laureate in England."

Mathematical, 22, Albemarle-street, W., 8 p.m.

Sat......Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,377. Vol. XXVII.

FRIDAY, APRIL 11, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

NATIONAL WATER SUPPLY.

The following letter has been addressed by H.R.H. the Prince of Wales, K.G., as President of the Society of Arts, to the First Lord of the Treasury:—

24th March, 1879.

My Lord,—As President of the Society of Arts, I have the honour to transmit to your Lordship the enclosed copy of a resolution, which was passed at a Conference, held by the Society in May, 1878, on the subject of National Water Supply. The Conference was held in consequence of a suggestion of my own to the Council, and it was attended by many of the most influential authorities on this subject in the country.

I need not urge upon your Lordship the necessity for providing a supply of pure water to the population of this country. At the present time, our great cities are endeavouring, each for itself, to secure a sufficient supply, while the smaller country towns and villages are dependent solely upon accidental sources.

Should her Majesty's Government be able to accede to the wishes of the Conference, by appointing a Commission such as that suggested, the first duty of the Commission would probably be to collect information. They would then be in a position to take measures for establishing such an organisation as might ensure that the existing abundant supplies of water should be dealt with in such a manner as to secure a regular provision, both in towns and country districts, of this first necessity for health and comfort.

The feeling of the Conference was that it would be better simply to urge upon the Government the appointment of such a Commission, without endeavouring to suggest the means which might be employed, after sufficient information was collected, to remedy the present state of things.

The growing importance of the question it would be difficult to overrate, nor can it be successfully dealt with except by the authority of the Government. The Society of Arts have already drawn special attention to it, and will continue their endeavours to promote its public discussion, but beyond this it is obvious they can no further go.

I have the honour to be
My Lord,
Your Lordship's obedient servant,
(Signed) Albert Edward P.
President of the Society of Arts.

The Right Honourable
The Earl of Beaconsfield, K.G.

[Copy of Resolution.]

Resolved :—"That this Congress desires to urge upon her Majesty's Government the importance of taking steps, with the least possible delay, to appoint a small permanent scientific commission, to investigate and collect the facts connected with water supply in the various districts throughout the United Kingdom, in order to facilitate the utilisation of the national sources of water supply, for the benefit of the country as a whole, as suggested by his Royal Highness the Prince of Wales, the President of the Society of Arts; and recommends that the Council of the Society of Arts be requested to ask Earl Beaconsfield to receive a deputation, to present a resolution and advocate its adoption."

The following is the reply of the Earl of Beaconsfield :—

(Copy.)

10, Downing-street, Whitehall,
31st March, 1879.

Sir,—I have the honour to acknowledge the receipt of your Royal Highness's letter of the 24th inst., forwarding a copy of a resolution passed at the Conference on National Water Supply, held at the Society of Arts, in May, 1878, and I have to inform your Royal Highness that I have referred the matter to the Board of Treasury for the careful consideration of their Lordships.

I have the honour to be, Sir,
Your Royal Highness's obedient servant,
(Signed) Beaconsfield.

UNIVERSAL CATALOGUE OF PRINTED BOOKS.

The following report has been addressed to his Royal Highness the Prince of Wales, K.G., President of the Society of Arts, and has been approved by him :—

May it please your Royal Highness,—The cost of producing a Universal Catalogue of all books printed in the United Kingdom, previous to the year 1600, having been referred by your Royal Highness to us as the Council of the Society of Arts, we beg leave to submit the Report appended, which we trust will be approved by your Royal Highness.

We have the honour to remain, Sir,
Your Royal Highness's most obedient humble
Servants,

Alfred.	A. H. Brown.
Westminster.	R. Brudenell Carter.
Granville.	Andrew Cassels.
Aberdare.	E. Chadwick.
Hampton.	Hyde Clarke.
Alfred S. Churchill.	B. Francis Cobb.
George Campbell.	H. Doulton.
U. J. Kay-Shuttleworth.	Douglas Galton.
	William Hawes.
John Lubbock.	H. Reader Lack.
Henry Cole.	W. H. Perkin.
E. F. Du Cane.	Robert Rawlinson.
T. Douglas Forsyth.	B. W. Richardson.
F. A. Abel.	John Simon.
G. C. T. Bartley.	C. E. Webber.
George Birdwood.	Erasmus Wilson.
F. J. Bramwell.	J. A. Youl.

H. Trueman Wood, *Secretary.*

REPORT.

I. The Council ordered certain questions to be addressed to librarians, publishers, and others interested in bibliography, which were printed in the *Journal* of the Society in February, 1878 (vol. xxvi., pp. 227-8-9). The Council then proceeded to meet in Committee, and took the evidence of Mr. George Bullen, the Keeper of the Printed Books in the British Museum, Mr. Nicholson, Librarian of the London Institution, Mr. Ernest C. Thomas, Librarian at the Oxford Union Society in 1874-5, Mr. Edward Arber, F.S.A., and others. The evidence of these witnesses was printed in the *Journal* in August last (vol. xxvi., pp. 856-68-81).

II. At the first meeting of the Committee, Mr. Bullen expressed the opinion that the best and only sure method of laying a solid foundation for the Universal Catalogue of English printed literature would be to print the Catalogue of the Printed Books in the British Museum, from A.D. 1450 to the present time, say, the end of the year 1878, representing about 1,250,000 vols., and comprising between 2,000,000 and 3,000,000 entries, *i.e.*, main titles and cross references (Ev. 170, 176). He considered the work might be ready for printing, "in a rough and ready way," in two years (Ev. 197, &c.), and in less time if more force were employed, and that it would take five years to print. All the witnesses agreed that the printing of the British Museum Catalogue would be highly desirable, and the Committee are of the same opinion. Mr. Bullen stated that the subject of printing a catalogue of the English books in the Museum, down to the year 1640, was "now practically before the trustees" (Ev. 142, 146).

III. The Committee find that, at three different periods, the Catalogue of the Printed Books in the British Museum has been printed in whole or in part: in 1787, in folio; in 1813-19, in 8vo.; and again in 1841, when it did not proceed beyond the letter A. The Committee are of opinion that the great size of the Catalogue affords no argument against printing it.

IV. The Committee recommend that, before the inquiry into the cost of printing the Universal Catalogue is carried further, it should be ascertained if the Government would entertain the idea of printing the Catalogue of the Printed Books in the British Museum, down to the end of the year 1878, in the *cheapest practicable form* suitable for use in all the Public Libraries, at Home, in our Colonies, and abroad.

V. To aid the inquiry, the Society has caused a Specimen Page to be prepared, in what would probably be the cheapest form that could be adopted. A larger type would add greatly to the cost, necessarily large in any case. The Catalogue is to be used like a dictionary, which is oftentimes printed in type much less distinct than that which it is now proposed to employ. It is a work to be useful occasionally, and not for reading, like history and similar subjects. If the Catalogue were printed and published as an ordinary Government publication, by the Stationery Office, it could be bought by the public at the cheapest rate—perhaps as low as 16s. or 17s. for a foolscap folio volume of 1,000 pages. If the edition were for 2,000 copies, the charge for each copy might be considerably reduced.

VI. The Committee cannot doubt that the Trustees of the British Museum would readily give all facilities for printing, and allow one of the sets of the titles of the books already made to be used by the printers.

VII. The Committee propose to circulate specimens of the page which has been prepared extensively at home and abroad, and to invite subscriptions for copies. If the Stationery Office would say at what price a volume could be published, it is obvious that the subscriptions would be all the more definite and satisfactory. It cannot be doubted that copies would be wanted in the United Kingdom, by the several Universities, and by the Libraries at Dublin, Liverpool, Manchester, Birmingham, and other provincial towns, now exceeding a hundred, besides by other Libraries out of England. The Libraries throughout the world might be asked to subscribe.

VIII. The Specimen appended to this Report contains 58 entries in the page. Assuming that the British Museum Catalogue has 2,500,000 entries, and taking an average of 55 entries to occupy a page, there would be, say, 45,500 pages, or about 45 volumes of 1,000 pages each.

IX. The national importance of this work, giving the information where one million and a quarter of the printed books of the world may be consulted, is great. Mr. Bullen says (Ev. 209), "No catalogue in the world, whether in print or in manuscript, is equal to that of the British Museum. It remains only that it should be printed to make this apparent to every one. I am often myself surprised at the historical information that it has compressed into notes, sometimes of a few lines, replete with knowledge. Some of the first scholars of the day, speaking bibliographically, have been engaged in its compilation." It would be of practical utility in the formation and improvement of public libraries at home, as well as in the Colonies and abroad, especially in the United States, and it would give general aid to the progress of Literature. The Committee, therefore, trust that H.M.'s Government will fully recognise the value of printing it, and authorise the Stationery-office to take the moderate risk of the publication of this work, already compiled, and nearly ready for printing. The Committee consider such risk would not be great, and that if the publication were properly made known, as it might be by the Society, an important portion of the cost would be defrayed by the sale of the Catalogue.

X. There are numerous minor questions of executive details and publication which the Committee will reserve for another report.

A specimen page, showing the mode suggested for printing the Catalogue, has been printed, and can be obtained on application to the Secretary of the Society.

AFRICAN SECTION.

Tuesday, April 1, 1879; W. H. PREECE, Esq., in the chair.

The first paper read was—

REMARKS ON AN OLD MAP OF AFRICA, CONTAINED IN SANSON'S ATLAS, PUBLISHED AT PARIS IN 1692.

Exhibited by R. Ward, on behalf of the Owner.

The atlas containing this map is a large folio, bound in calf gilt, in a very excellent state of preservation, and with the colouring singularly beautiful and fresh. It came into my hands about 30 years since, when travelling in Holland, and was given by me to the present owner, who has kindly furnished it for exhibition this evening.

The book professes to be a "New Atlas, containing all parts of the world, and in which are exactly marked the empires, monarchies, kingdoms, states, republics, and people which are found there by Seigneur Sanson, Geographer in Ordinary to the King; presented to Monseigneur le Dauphin by his very humble Hubert Jaillot, Paris, MDCXCII."

The map of Africa appears to be a compilation from the older Portuguese maps. The chief points of interest in it, which are worthy of note, are those which are brought together in the following memorandum.

Between the 5th and 13th parallels of south latitude there are two large lakes, some ten degrees of longitude asunder, which are named Lac de Zaire and Lac de Zembre, and Lac Zaflan, the two former names being common to the westermost lake. A river flows out from the north end of each of these lakes, and the two streams unite in the midway point of the continent, and two degrees above the equator, to form the Nile. It looks very much as if these lakes may have been traditional shadows of the Tanganyika and Victoria Nyanza. The Zaire and Zembre are large enough to be the Tanganyika and Nyassa in one. Near to the tropic of Cancer, the Nile is joined by the river of Nubia, sweeping into it from the west.

From the Lac de Zaire a large river flows also westwards to the Atlantic, through Congo, entering the ocean near San Salvador. Assuming that the Zaire is identical with the Tanganyika, it will become obvious that this is the river which is to be, according to Mr. Stanley, when the Tanganyika has risen high enough to accomplish its overflow into the Lualaba, through the creek which has been explored first by Lieutenant Cameron, and then by himself. But in the Seigneur Sanson's map, as the Lac de Zaire flows into the Nile as well as into the Congo, there is a wide continuous water-way, already laid down obliquely across the continent from the Atlantic to the Levant, and running in a north-east direction.

A little to the west of the great fork of the Nile there is a lake marked as the Lac de Niger, and from this the river Niger flows, through the Lac de Borno, which looks very much like Lake Chad, and not to the Bight of Benin, but boldly to the west, where it enters the Atlantic by two mouths, marked respectively Rio Grande and Rio Senega, which are manifestly the Gambia and Senegal rivers, with the Cape de Verde between them.

The Zambezi river arises in the Lac Zachof, in the Empire of Monomotapa, a few degrees to the north of the true place of Lake Ngami.

Some distance to the north of the proper position of Zululand there is a river designated the Rio de Spirito Santo, running into a curiously deep gulf, which is very tantalising, in the suggestion which it affords of a commodious harbour in the midst of this surf-barred coast.

The entire southern stretch of the continent consists of a vast empire, named the Empire of Monomotapa, which is embraced within a horse-shoe of sea line, extending from the Atlantic, through the Cape of Good Hope, far up into the Indian Ocean, and which figures as the Coste des Caffres. In this Caffreland there appears the Terre dos Natal, with the Land of Smoke (Terra dos Fumos) adjoining it towards the north. The Orange River is not noticed at all, and the Land of the Hottentots, through which this vast stream flows, is also conspicuous only by its absence.

The Empire of Abyssinia fills up the entire centre of equatorial Africa, and extends from 14° south, to 20° north latitude, and from the 45th to the 73rd meridian of east longitude. The country of the Negroes (Pays de Negres) occupies both sides of the long stretch of the hypothetical Niger quite to the 45th meridian (west from Ferro.) The Desert, or Sahara, is nearly conterminous with it on the northern side, and extends quite to the frontier of Nubia, with the River of Nubia draining it far more than one-third of its length on the eastern side. Guinea lies in a similar way between the Sahara and the Bight of Benin, which figures as the Guinea Sea (Mer de Guinée.) Barbary, with the kingdom of Barca, extends from Egypt to the Atlantic.

The longitudes of the map are reckoned from the old universal meridian of the west point of the Island of Ferro, which is, itself, 18° 10′ west of the meridian of Greenwich.

There are copies of this interesting old atlas in the British Museum, and in the University libraries at Oxford and Cambridge.

DISCUSSION.

Mr. Hutchinson described an old map of Africa, attached to a book which had been lent him by the Royal Geographical Society, and which tended to show that recent discoveries in Africa were but re-discoveries of what had been formerly known, so that, in more senses than one, Africa had been a lost continent. This was a map prepared by Pigavetta, chamberlain to Pope Sixtus 9th, and it contained all the principal features of the African continent. The two principal lakes, the Victoria and Albert Nyanza, were given, and the true course of the Congo was indicated. It was the only old map in which the real course of the Niger was given. It was also interesting to know that the Portuguese established a very complete sovereignty and control over the whole of the lower part of Africa, and their constant efforts to join their possessions on the East and West Coasts led to their comparatively accurate knowledge of the country. At one time also, the whole of this vast kingdom of the Congo was nominally Christian, and Lieutenant Grant had lately found that the King of Congo professed himself to be a Christian, and had some knowledge of the Romish faith, as taught him by his ancestors. The Portuguese, however, instead of consolidating their strength in any one spot, were led by their lust for gold to seek continually fresh conquests, and thus their power became weakened, and, ultimately, they had to succumb to the Zulus. The following is the title of the work by Pigavetta:—

Relatione
Del Reame di Congo,
et delle
Circonvicine Contrade,

Trana dalli Scritti & ragionamenti
di Odoardo
Lopez Portoghese,
Per Filippo Pigavetta.
Con dissegni et ari di Geografia, di piante, d'habiti, d'ainmali, & altro.
Almolto Illpre & Reme Monore Antonio Migliore Vesiono di S. Marco, & Commendatore di S. Spirito.
M. Roma,
Appresso Bartolomew Grassi.

Mr. C. Cooke said he had lately been looking at an interesting old map of Africa in the British Museum, dated 1588. There were seven maps there of that century, and the whole number of maps of Africa was 417.

Mr. Mast suggested that a map should be printed in the *Journal* to accompany the paper, which would add to its value for educational purposes.

Mr. Hutchinson said there were several old maps of Africa in the possession of the Royal Geographical Society, to which he had referred in a pamphlet he had just issued. The first was that of Ptolemy, in 150; next several which bore the stamp of Hindu geographers, but had no dates; then one by John de la Cosa, in 1495; the Florence Globe; next one by Bernhard Silvan, in 1511; then the one by Pigavetta, to which he had already referred; one by Diego Homen in 1588; the Antwerp map of 1590; that of Mercator in 1630; one by Vischer and De Witt in 1648; and the last by John Ogilvie, who was master of the revels to Charles II, in Ireland, in 1670.

The second paper read was—

SOUTH AFRICAN TELEGRAPHS.

By J. Sivewright,

General Manager of Telegraphs in South Africa.

Communicated by Robert James Mann, M.D.

The great guiding principle adopted in the construction of the telegraphs of South Africa has been to have everywhere alternative routes, so that, in case of the connection between two places upon a trunk-line being intercepted, communication can still be maintained between them in a roundabout way. The importance of thus having two strings to the bow is always kept in mind in telegraph construction, but it is exceptionally pressing and great in the case of South Africa, where the exigencies incident to passing through districts occupied by a capricious, and not always contented and orderly, native population have to be provided for. The country, happily, lends itself very readily to this necessity.

Pretoria, in the Transvaal territory, occupies the apex of a triangle, which is connected by two of its sides with Natal and Cape Town. When all the lines which have been projected have been completed, there will be hardly a town of any importance along these routes which will not have the advantage of a second method of communication, and with many of them there will even be a third. With such a system of connection, the Griquas might destroy many miles of wire without interrupting the communication between Natal and the Cape; or the Zulus, in the disputed territory on the Blood River, might destroy the section across the Drakenberg, and yet the connection between Natal and Pretoria be unbroken. From Cape Town the completed line runs north-eastwards, not far from the coast, through Kokstadt to Maritzburg, giving off seaward branches to Algoa Bay, Port Alfred, East London, and Durban, continued on to Stanger, in the Victoria County of Natal. An alternative upland line runs through Beaufort West, so as to form a junction with the lower line at Beaufort, giving off branches northwards, or inland, to Ceres, to Victoria West, to Kimberley, in the Diamond Fields, and to Aliwal North. From this completed line there are to be extensions to Bloomfontein, through Kimberley on the one hand, and through Aliwal North on the other; and from Bloomfontein the line will proceed to Pretoria, to which there will also be the alternative route, already in a forward state, through Maritzburg. The completed line, it will be observed, connects Cape Town with the western provinces of the Cape, Griqualand, Kafraria, and Natal, and the next extensions of the line will connect Pretoria (Transvaal), through Bloomfontein (Free State), with Kimberley, and by the alternative, and more roundabout route, through Natal, which will pass by Ladysmith and Newcastle.

In referring to the plan for telegraph construction in this district, it is, happily, not necessary to fight over again the old battle of road and rail, because railway construction is here yet in its earliest infancy, and already far outstripped by the telegraph. The lines of the telegraph, nevertheless, take broadly the routes which railways will ultimately follow. New stations from these will be easily supplied by short loops from the trunk lines. In the selection of routes in a country like Africa, the fate of the chosen line does not hang upon the will of petty landowners, or of crotchety householders. The field is quite clear of this form of difficulty. It is the plethora of land, and the bounteous freedom of choice, rather that presents itself as an embarrassment to projectors.

In the line first constructed, between Port Elizabeth and Cape Town, by the Messrs. Siemens Brothers, it was thought advisable to conceal the posts and wires as much as possible from traversed roads. It is not quite easy now to understand why this should have been done. But the line as made is certainly a good and successful one. The 500 miles of the line can only be, as a rule, followed on horseback at a walking pace, and in many parts the country traversed is impracticable by a horse, and occasionally even finds work for an expert in mountain climbing. The notion, however, that such a course was requisite to guard against wilful damage will not bear scrutiny. Wooden poles and iron wire are not of sufficient intrinsic value to stimulate theft, and the insulators are absolutely of no other value than for the purpose to which they are applied. Wilful damage is far more likely, in truth, to be attempted in hidden kloofs, and out-of-the-way places, than on routes visible from a high road. Thoughtless and undesigned injury is also more easily stopped in situations that are open to watching. The prime cost, and after maintenance, is certainly less along an unconcealed course, and faults are obviously more easily rectified, and impending break downs more readily foreseen and provided against. Traversed roads also invariably strike the "drifts," or fords, of rivers at the most convenient and accessible places. They are always found where the bed of the stream is the least confined, so

that the waters can spread out and admit of a shallow crossing. In the line which has been alluded to, the lineman in many places cannot follow the wires across rivers without making detours of many miles. Zealous officers have actually upon occasion been swept away in the attempt to make a direct and immediate passage of the river.

The argument for following roads, however, loses much of its force in the grass uplands of the eastern province, on the plains of the Orange River Free State, and along the low, rolling hills of the Transvaal. A bullock wagon, with the engineers' stores, can there make its way anywhere, and travellers on foot, or cantering on horseback, commonly prefer to strike across the open country rather than to follow the wagon track. The same state of matters prevails in many parts of Kaffraria and Natal. Hence the advisable course in laying down a new telegraph route seems to be :—1. To follow the highway, and to keep within sight of it in the bush, or bush veldt; and, 2. To take the shortest available route which, with due regard to good river crossings, can be taken by wagons or horsemen over the grass veldt.

The choice between timber and iron for posts is a matter which requires some consideration. The general and obvious disadvantages of timber are that it is liable to decay, to ravages from insects, and to accidental injury from bush fires. In districts destitute of wood, wooden posts are liable to be cut down for fire-wood. They are also convenient for the renewal of disselbooms, or poles of wagons, in case of accidents, and useful as shed supports, and are applicable to various other purposes. Iron posts, on the other hand, entail a large prime cost, and have their own electrical disadvantages in damp weather. Perhaps the best practical rule, under the circumstances, is to use timber for posts wherever it can be easily obtained of good, sound quality; and when this cannot be managed, to employ iron. Timber, not of the best quality, may also be turned to good account by adopting an organised system of maintenance, which includes "spurring" of posts at the wind and water line. It should never be forgotten also that, in all new countries, it is very advisable to make the largest possible use of natural products for public works. It is wise to keep the money circulating in the country, instead of sending it out in exchange for iron telegraph posts. This principle of course must be adopted discreetly, and not carried to an absurd extent.

In the western province suitable wood is not readily obtained. The fir grows near Cape Town with great rapidity and luxuriance; but on that very account it is open grained, and with the sap never really down, so that it is altogether unsuitable for posts in its natural condition. Creosoting, which is the only reliable method of preservation, is out of the question, because creosote is not to be procured in the colony, being an exceedingly objectionable article for shipment. It is found more practicable to import creosoted timber for posts, than to prepare it by creosoting native timber on the spot.

The silver-fir grows vigorously on the slopes of Table Mountain, but there is only a very limited supply. Oak, in any quantity, is not to be had. The Australian blue gum, which is largely grown, is not of suitable quality.

In the magnificent forests of the Knysma and Zitzikamma there is a wood which is of slow growth, and which is saturated by a permanent oil that renders it very durable. This is known as the "Waar olyven hoot," or olive tree. The timber is of quite unexceptionable quality, and, if plentiful, would at once altogether banish iron. Unfortunately, however, in this climate, where nature runs to riot in luxuriance of vegetation, slow growing plants are stunted in their development, and assume the proportions of large bushes instead of becoming trees. Olive wood, of adequate size, is, on this account, not abundant. It is used when found of sufficient size, and then, even after 18 years, shows no trace of decay between wind and water. It is, however, apt to warp above, and to split round the bolts. Iron wood, known as black iron wood in the Knysma, and as hard pear wood in the Zitzikamma, is procured, but not in large abundance, from the same district. It is also very durable, and furnishes poles 21 feet long, 8 inches square at the base, and tapering to 4 inches above.

In the eastern province sound timber of good quality, sufficient size, and adequate abundance for practical use, is first met with. It occurs in the form of what is known as the umtatie, or sneezewood, on account of the snuff-like properties of its irritating saw-dust. It is of slow growth, and is charged with a permanent oil. Trees 21 feet long, and with a circumference of 20 inches at the base, must be at least 60 years, and, according to some authorities, are not uncommonly a complete century old. The so-called oleaginous constituent is in reality a resin which is soluble in alcohol. Sneezewood poles are crooked and unsightly, but their ungracefulness is fully compensated for by their excellence. The tree, as it grows, is composed of bark, sap-wood, and heart-wood. In poles cut from the tree, about half an inch of the outside is generally sap-wood, which loses its sap after a few years, and may then be easily removed. The heart-wood which remains is practically indestructible. In 3,000 poles examined, which had been in the ground from 10 to 16 years, there was not one which manifested any trace of decay. A piece cut from an old pole burns as brightly as fresh resinous or creosoted timber. Sneezewood poles, on this account, are very convenient for lighting camp fires. Hence, established places of outspan should be scrupulously avoided in laying out a line. The crookedness of the pole happily makes it less desirable for the renewal of disselbooms.

The destructive influence of grass fires can be effectually guarded against by clearing a space, 12 ft. in diameter, round each pole, and maintaining the clearance. No instances is known where poles protected in this way have been destroyed. Sometimes they get charred by the heat, but they do not take fire, on account of the rapid passage of the flames.

The average weight of the sneezewood pole, of the dimensions specified, is 225 lbs. For lines far inland, on this account, iron has an advantage. The distance from a forest at which iron may be advantageously substituted for timber, depends, to some extent, upon the cost of transport. Three years ago, when the line to the Diamond Fields was constructed, each iron pole, at its peg, between Colesberg and Kimberley, cost the contractor 50s. At the present time sneezewood poles are

furnished on the Fauresmith-Bloomfontein Section, 250 miles from the base of supply in the forests of the Amatola Mountains, at 40s. each. Transport rates, however, have been higher in most parts of South Africa during the last season, than ever known to be before.

In regard to iron poles, lightness and strength are the qualities which have to be aimed at. The ribbed base, or buckle plate, with a ribbon-shaped tube fitted to carry two or three wires, is a commendable form. In a grazing country, cattle make less use of iron than wood as rubbing posts. They dislike both the heat and cold of the iron. Wooden poles are very commonly made quite smooth by the rubbing of cattle.

The wire in general use in South African telegraphs is galvanised iron of No. 6 gauge. Each section has to be looked at as one link in an extended, and still possibly extensible, chain. It does not therefore do to adopt any smaller gauge. There is an old form of ungalvanised wire, which was used by the Siemens Brothers, in 1873, between Fort Beaufort and Colesberg, which has answered very well. One thing which is especially needed for service such as that in South Africa, is some light kind of compound wire with relatively small resistance, such as the steel wire coated with copper not long ago invented. The transport factor varies, it must be remembered, directly in proportion to the gauge. The lighter wire also implies the employment of lighter poles, lighter insulators, and a general reduction in the weight of fittings. The momentous importance of this point will be at once understood, when it is stated that transport at the present time is at ruinous rates. On the 9th of December last, the rate from Durban to Maritzburg, a distance of 54 miles, was £15 10s. per ton. An occasional waggon could at that time be had, as a matter of favour, to take a load up to Pretoria, in the Transvaal, a distance of 450 miles, at £52 10s. per ton.

As insulators for the wire, the Andrew's porcelain, and Oppenheim—Australian pattern—are to be preferred to the iron-hooded form, where damage, either from wilful or accidental injury, is not to be apprehended. The double-shed brown earthenware insulators, adopted between Maritzburg and Durban, are an absolute failure. Their insulating capacity is good enough, excepting at times of dense fog, when their insulation becomes weak. They are also mechanically up to their work. But they are singularly open to injury from lightning. A storm rarely passes over a line where they are, without smashing from three to ten. A heavy charge enters the wire, and passes round the binder, and the condition of a charged Leyden jar is then produced, in which the wire and binder become the representative of the inner coating, and the bolts of the insulators, which, with iron posts, are in connection with the earth, take the place of the outer one. The section of the earthenware in such circumstances fails to prevent a disruptive discharge, the insulator is destroyed, and the wire brought to earth. At the point where the discharge takes place, a small globule of metal is raised on the wire, and a black discolouration is caused on the earthenware. The mechanical structure of the brown earthenware seems to provide a line of passage at that point. Along this route, portions of the line, furnished with Siemens iron-hood insulators, have given one injured in five months, whilst 50 per cent. of the brown earthenware have been destroyed within 18 months. All the poles are, of course, furnished with lightning protectors. In one place, where the line crosses the Stormberg Mountains, between Dordrecht and James Town, even the iron-hooded insulators on wooden poles, are, however, frequently damaged.

The Andrews insulator seems to leave little to be desired, except, perhaps, a trifling improvement in cutting short the porcelain covering of the stalk. One great excellence in the Oppenheim insulator is the absence of cement for fixing the pin to the cup. The attachment is made by a screw, and on this account the iron and porcelain parts can be packed sepatately for transport, which is a valuable provision in traversing a rough country, and also a great convenience in effecting repairs. It is a good procedure to substitute a wooden pin for the iron one in these insulators, wherever lightning is especially troublesome. The wooden pin also gives increased immunity from fracture of the porcelain, under the influence of great vicissitudes of temperature. The coefficients of expansion in porcelain and iron are much more widely severed than they are in porcelain and wood.

The iron-hooded insulator should, as a general rule, be had recourse to where damage from accidental mechanical causes is liable to occur, and then the Indian pattern, with the wire bound to each insulator, is to be preferred to the plan sometimes adopted of suspension from a hook, with a strainer at every seventh pole. In all other situations, the Oppenheim insulator, with a wooden pin substituted for the iron ore, should be used.

The roads in South Africa are, in many places, merely wagon tracks drawn across the Veldt, and as one track becomes cut up, or heavy, another is opened, until, in some instances, the road grows to 100 yards in width. Hence the ordinary rule of bringing the last pole, near a crossing, up as nearly as possible to each side of the track, becomes inapplicable. In such situations trenches are generally dug, with a radius of six feet, round each pole, and filled with stones. Wagons, nevertheless, still run up against the poles, especially at night. A wooden pole has an unmistakable advantage over iron; it stands a much less risk of being smashed in a collision. With a sneezewood pole the wagon often comes off second best from a conflict, and it is therefore treated by transport riders with a larger measure of respect. Between Komgha and Butterworth, a distance of twenty-six miles in the Transkei, where there are iron poles, seven interruptions of the circuit have occurred from this cause since the opening of the line in September last; whilst no stoppage at all from the same cause has occurred between Butterworth and Maritzburg, where the poles are of sneezewood.

When more wires than one are carried along upon the posts, contacts between them are very apt to be set up on road-crossings, by the "vorschlaght," or thong at the end of the long whips, being swung round them whilst flogging the oxen. Road-crossings most commonly occur at some rising ground, where the lash has to be vigorously applied to his team, by the driver. To meet this cause of injury, poles are placed as close

as possible at such spots, and straining insulators used, with the wire stretched as tensely as possible. Sometimes each wire is run 30 or 40 yards away from its neighbour on a separate line of poles, and the two wires are only brought near together when the line is beyond the reach of the vorslacht. Such, however, proves to be only a sorry shift. A better expedient is to employ double poles with six feet arms, carrying one wire at each end. The line wire is then shackled off, or double bound and soldered at each side to an invert, and light steel No. 12 wire is used for the absolute crossing.

When straining insulators are used, the wedge form is the best; but great care is necessary in driving the wedge home, so as not to nick the wire. If nicked the wire will break there at the first frost, and, at long spans, there is even danger of the wire getting worn through by friction against the edges of the wedges. The eccentric form of insulator can only be depended on along very flat ground. If the ground is much broken, the nut refuses to take a proper grip, and the wire slips under the slightest applications of force. Even variations of temperature are sufficient to draw the wire away from the eccentrics. In broken country not one eccentric in ten stands properly to its work after having been in use a couple of years. Some portion of this imperfection is due to careless workmanship in straining. But that cannot be obviated, because the telegraph engineers in rough countries rarely get the chance of choosing their skilled workmen.

Black iron coach screws are better than galvanised iron screws for fixing iron-hooded insulators or iron brackets to the poles. Galvanised iron screws are very liable to break off, in consequence of the brittleness communicated to them in the operation of galvanising.

Upon the whole, there is a remarkable and even surprising immunity from damage by lightning with the telegraph lines in South Africa, which would hardly have been looked for where thunderstorms are so frequent and so severe. The explanation of this most probably is, the sparseness of the lines, and the limited number of the wires. The areas concerned in the thunder storms are very large, and, in regard to them, the tracks of the telegraph lines of great relative minuteness.

Every pole in the South African system of telegraphs has its lightning-protector, made of the same gauge as the line-wire, and sharpened at the point, which is raised two inches at most above the top of the pole. Not very long ago, a fiat was issued in South Africa that all lightning-protectors were to be done away with, because they were more trouble than they were worth. The protectors, however, which earned this proscription for themselves, simply sinned in being unnecessarily long. A notion prevailed that they must extend 18 inches above the pole to be of any use, and they were then liable to be driven into contact with the line-wires by the roosting of birds, and by other disturbing agencies, and so to cause full earth. These difficulties are, however, all obviated by the simple expedient of docking them of their redundant length. The lightning-protectors are also liable to become troublesome from loose staples. When only one wire is suspended from the poles, a very good plan is to wind the lightning-protector spirally round the post. A very excellent proceeding, also, is to bore a hole some distance through the top of the pole, and thread the wire of the protector through it. Two staples are then used at the top of the pole, and other staples fixed six inches apart for three feet down, and 12 inches apart afterwards.

Thousands of dry, imperfectly soldered joints have had to be cut away from the South African lines within the last eighteen months. More careful joining is now universally insisted upon. The Fletcher's soldering apparatus, with a 24-inch handle, with cotton waste steeped in paraffin as fuel, is in use, and proves of inexpressible value. For leading in wires, gutta-percha is of no use; it becomes worse than good-for-nothing in a few months. The Hooper's compound employed by the Telegraph Department of India is the best insulating covering for wires that has hitherto been adopted.

In dry tracts of country the greatest imaginable difficulty is found in making earths. Along the dry, and often absolutely rainless karoo, the wires have to be carried to the river beds, or rather to the sandy gullies, where there would be river beds if there were any water, and earth-plates have to be buried in these. Occasionally, Steinhilt's historical method of making a rail serve the purpose of a second wire is turned to account. Where this cannot be done, a pipe is often carried to the earth-plate, and water poured into it by one of the officers or attendants every morning.

My conviction of the practicability of carrying a line of telegraph overland through the interior of Africa is already on record. The experience which has been gleaned during the last nine months in travelling through the country, from King William's Town to Pretoria, and in conversing with men possessing local experience; and a more or less intimate acquaintance with the physical and social conditions concerned, has materially tended to strengthen this conviction. The problem to be attacked is not, however, it must be understood, the carrying of a line for 4,000 or 5,000 miles through an unknown wild country, as is generally supposed. The distance which would have to be traversed for the completion of the African line is only 2,400 miles, and even this is conveniently divisible into three workable lengths of 800 miles each. Almost immediately there will be a telegraph in operation to Pretoria from Maritzburg, and that, therefore, may be taken to be the southern limit of the gap which has to be filled. The northern limit will soon be at Gondokoro, on the White Nile, to which point Colonel Gordon is pressing on the construction from the 8th degree of north latitude, above Cairo. The distance from Pretoria to Gondokoro, as the crow flies, is not more than 2,000 miles. The most practicable course in filling up this gap is from Pretoria to pass through Shoshong, the capital of the Bamangwato tribe, and Gubuluwayo, the residence of Lobengulu, supreme chief of the Amandabeles. From Gubuluwayo to Tete, the Portuguese settlement on the Zambesi, is certainly not more than 300 miles. From Tete to Zanzibar the line would pass through Blantyre or Livingstonia, the Scotch mission settlement on the Shire and Lake Nyassa. From thence there is a practicable route to the Zanzibar terri-

tory, near Cape Delgado, along the track which was traversed upon one occasion by Livingstone. From the frontier of this territory to Zanzibar could be passed, according to the testimony of Dr. Kirk, "with perfect ease and safety." Zanzibar, it will be remembered, is a great natural centre of commerce. It has a growing trade with Europe, Asia, and America. It has three lines of monthly steamers; namely, that to Mozambique, Natal, and the Cape; that to Aden; and the French line to Mozambique and Madagascar. The Port is also the head-quarters of the eastern division of the African coast naval forces of Great Britain. The weakest link in the chain is undoubtedly that which lies between Zanzibar and Gondokoro, and which is, in itself, 800 miles long. The direct route for this lies over the Kilimandjaro Mountains, and thence round the north-eastern angle of Victoria Nyanza. But there is an alternative route for it by the caravan road from Zanzibar to Ujiji, on Tanganyika, and thence through the country of Uganda. This, although a somewhat more roundabout way, would have the great advantage of traversing one of the richest agricultural regions in the world. And yet again, if, for any unforeseen reason, this part of the line proved impracticable, the wire might be taken along the coast from Zanzibar to the point which is immediately opposite to Aden. The obstacles which have to be specifically dealt with in a work of this kind are; the difficulties of transport through rough country; the dangers which may lurk in the interior of unknown territory; the opposition of hostile native tribes; the troubles incident to effective maintenance in a rude land; and the injuries to be apprehended from wild animals inhabiting the region. Obstacles of this class have, however, been all encountered and conquered in other instances, which are not by any means dissimilar to the work in Africa. The Russians have successfully carried a telegraph across the Steppes of Siberia. The Australians have done the same thing, through the heart of their vast continent, from Adelaide to Port Darwin. The North Americans have conveyed the wire across the prairie, the Sierra Nevada, and the Rocky Mountains. In South America the telegraph now runs from Buenos Ayres across the Andes to Lima, and through the heart of the tropical forests of Brazil; and lastly, there is the great Indo-European telegraph which is as well worked as any line in the world. In referring to tho difficulties of transport, attention should, porhaps, be drawn to the hope which lurks for long overland lines in the new form of compound wire, which consists of steel encased in copper, and which will certainly suit admirably if it prove durable. Such a wire would electrically serve as well as an iron wire. A ton may be safely estimated as sufficient for 12 miles of line. On the telegraph lines of the Indo-European Company, subsidies to chiefs have practically quite obviated all risks of barbarous interference; the chiefs, indeed, in most places, have learned, under the operation of this system of subsidy, to look upon the telegraph line as a valuable kind of property to themselves, which it is expedient for them to guard with jealous care. In regard to the question of the unhealthiness of the country passed through, it will be understood that it is not necessary to have a white man at every telegraph post. There would only need to be stations about 200 miles apart, with runners between, with whom there would be some standing arrangement to indicate the condition of the intermediate section of the line. Constructing parties would only enter such fever haunts as the valley of the Zambesi at healthy seasons of the year, and, for inspection and maintenance, salted and acclimatised half-castes, and even natives, could be drawn upon for much useful service. So long as Kafir workmen can be kept from the canteen, looked after, and judiciously handled, they really make excellent line runners for telegraph maintenance.

The advantages which overland lines possess over submarine ones, when they can be carried out, are so obvious that it can scarcely be necessary to do more than touch upon them in the most cursory way. They cost much less money. In the case of an African overland telegraph, in all probability about £200 per mile, or, in round numbers, half a million sterling for the 2,400 miles, would be ample for the construction. The overland line is more reliable for service; its interruptions may be more frequent than those of a submarine cable, but they must be of very short duration, whilst a submarine cable once injured may remain silent for months. An overland line begets traffic along its route, and creates intermediate self-supporting stations. An overland line, as soon as it is constructed, constitutes a real solid property, which may be reckoned upon, with a fair measure of certainty, to last for years. The submarine cable, on the other hand, may fail at any moment, and become practically valueless. There can be no greater mistake than the old notion that a telegraph cable is out of harm's way when it is once at the bottom of a deep sea. The submarine cable, like everything else, has its own appointed term of life. When a cable is once put down in a deep sea, its process of destruction begins; with the action of oxidisation upon its outer sheath of wires its weight augments, and its tensile strength diminishes from day to day. As soon as an old cable is lifted some distance from the bed of a deep ocean, the suspended weight becomes too great for its strength, and away it goes. This is of great practical consequence, because however well a cable may be made, and however well it may be laid, circumstances, in reality, arise which impair its electrical power, and necessitate its being overhauled from time to time. The lowest estimate that could be allowed for a submarine connecting trunk between South Africa and Aden would be £1,000,000 sterling;* and a repairing ship for its maintenance would cost £12,000 per annum.

As an alternative route, to guard against the evils of suspended communication under the influence of accidents, any second line of communication, by a different course, must always be of exceeding value. On this account a connection with Aden is to be greatly desired, especially in the face of the fact that it is the one central spot in the great telegraph system, beyond all others, where the largest number of alternative routes converge.

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* It is understood that the submarine cable which is to be laid from Aden to Zanzibar by the Eastern Telegraph Company, and which will run intermediately through Zanzibar, Mozambique, and Delagoa Bay, will cost between £900,000 and £1,000,000.

DISCUSSION.

Dr. Mann said he believed the Eastern Telegraph Company had already undertaken to construct a cable connecting Natal with the European lines, going from Aden to Zanzibar, thence to Mozambique, to Delagoa Bay, and so on to Natal. The estimate would, he believed, be between £900,000 and £1,000,000. He had with him a report of the Commission appointed by the Royal Geographical Society to consider the question of an overland telegraph in Africa, some parts of which were interesting. Having read the passages in question, he said that in considering this question of telegraph route there were two distinct points from which it was approached. First, those who were interested in the advance of Africa must desire the overland route above all things, but on the other hand that would take some time to construct, and the emergency which had just arisen in and around Natal, had brought the question to an issue, and shown the immediate necessity for laying a submarine cable.

The Chairman said one of the distinguishing characteristics of the English telegraph system was, that every town of any consequence should have what Dr. Mann had called an alternative route. Those who were in the habit of using the telegraph, knew that by no chance were they ever prevented from communicating with any town, and in arranging a system for South Africa this had been borne in mind. The burning question which had arisen at the present moment involved the necessity of establishing a communication between the mother country and South Africa as speedily as possible, but whether it was carried out by a land wire or by a submarine cable, this question of an alternative route would eventually come to the front. If they had a land wire, they must have an alternative route in the shape of a cable, and if they had a cable they must have an alternative in the shape of a land wire. The great point upon which he would invite discussion was the practicability of the two routes, and the difficulties attending each.

Colonel Grant said that during the last six months the Geographical Society had also had a communication from Mr. Sivewright upon this subject, he having been consulted with reference to an overland line between Pretoria and Egypt. Sir Bartle Frere was also consulted, and gave his opinion that such a line could be made across the country, though without binding himself to a preference for an overland line as compared with a cable. The greatest difficulty which occurred to him, with reference to telegraph lines, was that in grassy countries the natives every year set fire to the grass, in order to get a good crop for the cattle when the rain fell, and some people feared that the posts would get burnt down, but they heard now that the grass burnt so rapidly that it merely scorched the surface of the posts and did not injure them. In Africa, particularly in Central Africa, the larger animals, such as elephants, rhinoceroses, and large deer existed, but he did not think that they would do that harm to the telegraph line which some people imagined. They were not very numerous, and the posts could be protected from their assaults, either by digging a ditch round each, or by placing thorns around them. Then it was said that the natives were very fond of wires, which in fact formed their coinage, and this would be a difficulty. But it so happened that telegraph wire, when galvanised, could not be welded together to make ornaments, such as ear-rings, necklaces, and bangles; and he should say that constructors of telegraph wires ought to take with them some kind of wire which would be useful to the natives, and which they could sell or make presents of to them, and then they would never attempt to touch the telegraph wire. He did not know much of the country except northward from Zanzibar to Egypt, and there were no natural obstacles throughout the whole of that distance worth mentioning. There were no mountains, no deep rivers, no extensive swamps, and not many deserts—except perhaps for 300 miles inland from Zanzibar, and even there they would not be above 40 miles across. But they must not go by force, but must pay their way, as the English Government did in Persia, where they paid the chieftains up to the rate of £4 per mile per annum, to allow the telegraph wire to pass over their country. If the Africans were treated in the same manner, paying them £1 per mile, or, as Commander Cameron said would be sufficient, 10s. per mile, they might get the line protected both from animals and plundering. Maintenance would no doubt be a heavy item, and he did not say that the line from Pretoria to Egypt would pay commercially, but it must be subsidised by the English Government, and by the Portuguese and other Governments. As to the amount, he thought a subsidy of £50,000 a year would be sufficient. He looked upon it as a paying concern, because it would introduce civilisation. At each station there would be intelligent young men, who would spread knowledge among the people, and in that way it would pay eventually. It was just as easy to lay a telegraph line in this way as to establish mission stations. The French, the Dutch, the Germans, and the Belgians were colonising, and sending missions there, and the best results had been obtained by gentle means. With regard to the cable, he was told by a gentleman the other day that it was not quite decided whether the line should run direct to Aden or India. It was about the same distance either way. Supposing it went to India, it would go through the Mauritius; whereas, in going to Aden, there would be stations at Mauritius, Zanzibar, and Aden, and it would run along the shallow coast, which he thought would be dangerous for the line, as there was much coral formation, which cut the line like a file, especially with the strong currents which prevailed there. He, therefore, thought the safer route would be to India.

Dr. Mann said he had been much struck with one point in the report from the Geographical Society, with regard to subsidising the natives for protecting the cable. An estimate had been made that this could be done for a yearly outlay of £4,000, which was about a quarter of the cost of the maintenance of a ship for attending to a submarine cable.

Mr. Hutchinson supposed there was no doubt that the die had been cast, and that a cable would be laid, in accordance with the inquiries to which references had been made, but he doubted if all the difficulties of this route had been taken into account. One of these, if the line to Aden were chosen, was the wonderfully strong current which ran north and south with the monsoon; and he did not see how a vessel could pick up, buoy, and repair a cable under such circumstances. The Church Missionary Society had a very strong steam yacht, which lay in Mombassa harbour, of 30 to 40 h.p., and capable of steaming seven knots an hour, but when the monsoon was the wrong way, it was found utterly impossible for her to make any way against the current. This existed all up and down the coast, and was a very serious matter for a cable. He did not consider an inland line by any means the wild scheme which some people had called it. We were learning more and more of the character of the country and people. Colonel Grant had disposed of the difficulty which seemed to have pressed on Sir Michael Hicks Beach, with regard to wild animals. With regard to making arrangements with the natives to protect the line, that was a matter on which more light was being thrown every day. It was well known that a troublesome duty, called *hongo*, had to be paid in passing through the Ugogo, and in that part at any rate, some arrangement would have to be made with the chief; but from very recent information, he could say that there was a

growing disposition to appreciate the motives and purposes of Englishmen, and to place confidence in them. The people were even beginning to invite settlers amongst them. Dr. Baxter, the chief of one of the mission stations, had lately been a journey of 17 days into the heart of the country, to buy sheep and goats, and he had brought down a flock of 200 or 300 without paying *hongo*. On the shore of Lake Nyanza, they had a store where they kept engines, anvils, tools, &c., belonging to the missionary establishment, and after they had been left in the hands of the native chief for some time, there was nothing found missing, except a few carpenter's tools. These people were amenable to kindness, and understood arrangements by which they were to make some return for what they received. Moreover, there was growing up a strong Government over the whole line from Gondokoro to Zanzibar. King Mtesa was a sovereign of great importance, and he had received their mission in the most friendly way. There were several other stations already established by his own and the London Missionary Society, as well as by the Belgian expedition, so that there would soon be stations occupied by white men from Zanzibar up to the lake, and from there up to the country of Mtesa, and on to Magungo. If they took their proper position, and did not coerce the natives, but treated them kindly and considerately, such a preponderating white influence would be established, that the protection of the telegraph lines would be easily accomplished. He thought the time had come when the English Gavernment should take a step in advance, and endeavour to get the Sultan of Zanzibar to exercise some kind of control from the coast up to the lakes. The only difficulty at present was near Unanyembi, and that belonged to the Sultan of Zanzibar, and as soon as peace was restored there would be a fair chance of things being put on a satisfactory footing. But as long as such men as the Abbé de Beyes took the law into their own hands, and shot people because they belonged to a strange tribe, there would be difficulties. It was now known that the murder of their own man, Mr. Penrose, was entirely due to this cause. No doubt a cable would have to be laid to meet the present emergency, but an alternative land line would also have to be kept in view. He hoped, not only in the interests of telegraphic communication, but of Africa generally, that such a line would be carried out, for nothing would more tend to promote peace and civilisation if it were in good hands. It would probably have more immediate results in this direction than even the operations of the missionary societies, because the latter had not such means at their disposal.

Mr. Cooke said when he was in New York, in 1859, he heard a lecture by Horace Greeley on the subject of a railway to San Francisco, and great difficulties were then anticipated by many people in the construction of that line, from buffaloes and wild Indians. They had not, however, proved really formidable, and he believed the same would be the case with telegraphic communication in Africa.

Dr. Mann said there was a great deal of truth in the remark made by Mr. Hutchinson on the civilising influence of telegraphs. If a wire were carried for 4,000 miles across the continent, and the natives were subsidised to protect it, those who received such subsidy would become civilised to that extent at least; they would get to understand what the meaning of civilised life was, and what doing work for remuneration meant, and in this way the thin end of the wedge would be effectually introduced.

The Chairman said the subject of South African telegraphs was one which had occupied his attention for a long time. As Consulting Engineer to the Crown Colonies, he had had a great deal to do with it, and also as Electrician to the Post-office. The subject had been recently before the authorities, who had had to consider the different schemes proposed. The question resolved itself, first, into a decision between the adoption of a land wire or a cable, and in each case there had been two or three routes to select from. With reference to the land wire, there were three distinct routes proposed by the Geographical Society and by others—the West Central, the East Central, and the Coast line; and so with reference to the cable. There was the one advocated by Mr. Donald Currie, starting from St. Vincent, on the west side, and coming down to the Cape; another, on the east side, starting from Aden, going down to Zanzibar, and through the Mozambique Channel to Delagoa Bay and Natal; and the third going direct to India, either by the island of Socolra, or in connection with the Indo-European line in the Persian Gulf, and across from the Mauritius to Ceylon. After considering all these schemes, the only feasible one seemed to be that proposed by the Eastern Company, skirting the coast and going through the Mozambique Channel. The two main matters to be considered were time and money. The Eastern Company had already constructed 1,400 miles of cable for Australia, which they were willing to employ for this purpose. Then there was the question of money, which was a very important one. It was met in the first instance by the subsidy granted by the different local Governments and by the Home Government. The subsidies altogether proposed to be given by the Cape Colony, Natal, the Portuguese Government and the Mauritius amounted to over £30,000 a year, and the receipts to be obtained from the line had been estimated at from £30,000 to £50,000. Taking these facts into consideration, with the cost of maintenance and interest on capital, the Home Government would be called upon to find a guarantee of something like £60,000 a year, for the annual cost could not fall far short of £100,000. That question was not yet settled, for there were different points of detail, particularly with reference to the question of guarantee. The company pressed for an unconditional guarautee, whilst the Government contended that they were not bound to give a guarantee for a cable not in working order. These details, however, would undoubtedly be soon settled, and the laying of the cable commenced; in fact the *Kangaroo* was uow ready to lay it to Delagoa Bay and thence on to Mozambique. He feared it would not be laid in time to assist in settling the disturbances in Zululand, but before the end of the year he hoped there would be a permanent cable established; but even then a land linc must, sooner or later, be constructed. A cable in itself was a mere lottery, and so was a land line, for they were both surrounded by difficulties. Those supposed to be met with in the land line were various; first there was the obvious one of the risk of going through an unexplored country, but they had heard from Colonel Grant and Mr. Hutchinson how easily some of these difficulties might be surmounted. A great deal had been made of the lawless character of the inhabitants of the country through which the line would pass, but they had been told how easily these lawless people could be made subservient to order. Some one had asked the questiou how could you expect a line of gold from London to Inverness could bc maintained, meaning that the idea of a line of iron from Zanzibar to Gondokoro would be of the same value there as a line of gold would be to the inhabitants of Britain, but, as Colonel Grant had said, if the natives were supplied legitimately with the ornameuts they required, they would readily leave the telegraph alone. His own idea was that if they occasionally passed a strong current through the wires it would give such a shock to any meddlesome natives as would prevent them ever touching the wires again: This had been done on one occasion, when they had a large quantity of submarine cables lying at Holyhead. Little boys used to go and cut off pieces of it; so one day they put on a strong battery,

and soon heard horrid shrieks and screams, and the little wretches were so frightened by the strong shock that they never came a second time. Again they heard a good deal of the unhealthy climate, and how impossible it would be for Europeans to live there and keep the line in order, but judging by the appearance of those who had returned, although there might be severe temporary effects, yet with increased knowledge and attention to hygiene, even this difficulty might be surmounted. Another difficulty was that of the transport, and one gentleman had said that it would require 124,000 coolies to transport the poles, but he thought that was a great exaggeration. Mr. Sivewright had put the transport at 50s. per ton a mile, and £52 10s. per ton for waggons, but these were exceptional figures. He thought himself that, with the knowledge now possessed of the country, there ought to be no greater difficulty in transport for 2,000 miles than for 200. Then they had heard about the wild beasts, the fly, and the swamps; one gentleman had told him elsewhere that he had been sent out to Zanzibar to make a road, and after constructing 28 miles he came back, and though he had grubbed up everything for a width of 20 feet some six weeks before, his road had disappeared through the rank growth of vegetation having obliterated it. How far this would affect telegraphs he could not say, but it occurred to him that if vegetation grew 10 feet high they could make the posts 20 feet, and if vegetation grew to 20 feet they could put the posts 10 feet higher still; there must be a limit to it somewhere. The difficulties from beasts and fire had already been dealt with. Altogether he trusted more to local experience than to fireside philosophy. It was very easy for gentlemen to sit at home at ease, and evolve all these practical difficulties from their inner consciousness, but those who had been in the country almost without exception agreed that the construction of a line was practicable. With regard to cables, it was very easy to draw a red line on a map, lay a cable down there, and imagine it would last for ever, but it was very different in practice. He had 62 submarine cables under his charge, and every year, more or less, had to provide for their repairs. There were many difficulties to be surmounted, especially in seas that had not been surveyed. In the first place, there were difficulties arising from imperfections in the manufacture, and though every fraction of an inch was carefully examined, and tested by the most searching instruments, imperfections did pass which ultimately showed themselves in the shape of faults. Again, there were faults arising from carelessness in the making of joints, and so on, and in the process of submerging, especially in deep-sea cables. In laying the Direct United States cable, they were three or four times stopped by a fault, which occurred through a little bit of wire having been accidentally thrown on the cable in the tank, and getting into it in passing over the wheels. Again, you had sometimes had to lay a cable in an unfathomable depth, where life was prolific and of a character of which you were ignorant. Of all the seas under the control of England, none was so badly surveyed as this on the east coast of Africa; it was a sea where no *Challenger* had been, and no Charles Darwin or Wyville Thomson had examined the nature of the bottom or the character of the life which existed there. Yet, in some seas, there were little insects which bored their way through the gutta-percha, and the interstices of the wire, and exposed the copper; accidents from this cause had been frequent in the Indian Ocean, and now cables for laying there were served with a lapping of thin brass to prevent this danger. Volcanic action, again, might be a source of danger, though he did not know that it would be in this instance. One great source of difficulty was the unevenness of the bottom. It was generally assumed that the Atlantic from Ireland to America was so smooth, that Professor Huxley in one of his books said it would be possible to wheel a waggon all the way; but the experience of the expedition sent out to repair the Atlantic cables showed that the bottom was so uneven that the cable did not lie upon it, but hung suspended from point to point, and so got corroded, weakened, and broken, the result being that the two cables laid in 1865 and 1866 had been entirely lost through this cause, and could never be recovered. Coral was not a pleasant thing to lay a cable upon, but still it existed in the Red Sea and other places where cables were laid, and he did not apprehend any very grave danger from this cause. The most serious difficulty was the existence of the monsoon currents which had been spoken of, which would greatly enhance the cost of maintenance; and so, taking all these things into consideration, he doubted whether the construction of the land line would be long delayed. Mr. Sivewright now advocated a line which would skirt the coast to Zanzibar. Whether it should then go to Aden or join the Egyptian line was a question; no doubt Colonel Gordon was a splendid fellow, but their experience of the Egyptian lines did not lead him to hope for much from them; and he thought it would be better to have a line to Aden, from whence there was direct communication either by the Red Sea and Mediterranean, or by way of India and the Indo-European line, than an uncertain Egyptian one. If they could only get a few more supporters like Colonel Grant and Mr. Hutchinson, he was sure the Colonial authorities would be ready to reconsider the matter. He concluded by proposing a vote of thanks to Mr. Sivewright, which he should have much pleasure in communicating to him.

The resolution having been carried, **Dr. Mann** proposed a vote of thanks to the Chairman, which concluded the proceedings.

MISCELLANEOUS.

THE MODERN HISTORY OF GUNPOWDER*.

We can modify the rapidity of ignition of powder, first, by varying the size and form of the grains or individual masses; secondly, by varying the density or compactness of the powder; and thirdly, by variations in the finish, or the nature of the surfaces of the grains or masses. These are the three most important means which have, up to the present time, been used, and with success, for producing the necessary modifications in the action of fired gunpowder. I will just show you the difference in the rapidity of combustion of gunpowders of similar composition but of different sizes. Here we have fine grain or small-arm powder; here is the old cannon powder used in small-bore guns, and for a short time in the earliest Armstrong guns; and here is a large-grain powder, subsequently manufactured for rifled guns. This large-grain powder was, at the time of its introduction, regarded as a great advance in the modification of the rapidity of burning of powder; but within a short time it became evident that this powder was too violent in the heavier of the charges which had to be used. The next step was to produce a powder of much larger size, and of uniform shape and size, by powerfully compressing meal powder into small cylindrical moulds, and thus obtaining pellets of powder about $\frac{3}{4}$ inch in diameter and $\frac{3}{8}$ inch in height, the inflaming surfaces of which were increased by partially perforating them. This was the first very large powder which was introduced in England for heavy guns, but

* Concluding portion of a lecture recently delivered in the Free Trade-hall, Manchester, by Professor Abel, C.B., F.R.S.

a very large grain powder had just previously been introduced in America, under the name of "mammoth" powder, and a much larger powder, of prismatic shape, also of American origin, was adopted about the same time in Russia and Prussia. Soon after the adoption of pellet powder, in order to facilitate manufacture, a powder of similar dimensions to the pellet, but of irregular size, was produced by us, not by moulding meal powder into distinct masses of uniform size, but by compressing it into thick cakes, and then breaking these up into pieces of a particular average size, which were afterwards deprived of sharp edges and angles and well glazed. The name of "pebble" was given to this powder. The average size of the pebbles is about $\frac{5}{8}$ in. by $\frac{1}{2}$ in., and one of them has about the same weight as 110 particles or grains of the rifle large-grain powder which I just now showed you. I will now compare the burning of these descriptions of powder, and you will notice the great difference which the size of the individual particles makes in the rapidity of explosion, even when the powder is fired in the open air.

These powders are all similar in their composition, and not very greatly different in density; but the modification of the density and compactness of powder, as I have said before, constitutes a very important auxiliary means of modifying the rapidity of action of fired gunpowder.

Although the pebble powder was found to furnish far more satisfactory results than the rifle large-grain powder, or even than the pellet powder which just preceded its introduction into our service, it occasionally exhibited a serious want of uniformity in the pressure which it exercised in the gun, especially when it came to be employed in the so-called "Woolwich Infants"—the 35 and 38-ton guns which until quite recently were the heaviest guns in our service; projectiles weighing from 700 lb. to 800 lb. being fired from them, with charges of 120 lb. to 160 lb. of powder. Occasionally, even in smaller guns than these, some exceptionally severe pressures were found to be exercised by this powder in some parts of the gun. The cause of these occasionally unfavourable results were very carefully investigated by the committee entrusted with this work. In some cases they were traced to an exceptional irregularity in the size and shape and density of the individual masses of powder, but they were also found to be connected with other conditions which occur in the firing of heavy charges in guns, and which I regret that time prevents me from discussing in detail. I must content myself with just referring to one of these disturbing causes.

As long as we had only a small cartridge to ignite, it mattered little where we ignited it, whether at the top or at the end furthest from the shot, the ignition took place throughout with comparative uniformity. But as soon as the cartridges were considerably increased in size, and the column of powder became a comparatively long one, it made a considerable difference where the cartridge was ignited, especially when we came to deal with a comparatively slow burning powder. If the cartridge was ignited at the rear, the gases produced by the first ignition, rushing with great velocity towards the shot, would be checked in their career by the inertia which it opposed to them, and thus, before the whole charge was ignited, irregular and locally violent pressures, so-called wave-pressures, would be produced in the bore of the gun. This action was in the first instance diminished, if not quite got over, by the simple expedient of placing the vent of the gun in a position towards the centre of the charge, so that the flame produced by the first ignition could spread more rapidly through the different parts of the charge. But when we came to use such enormous charges as those of our latest guns—the 80 and 100-ton guns—charges of from four to five hundred pounds, contained in cartridges 60 inches and upwards in length, then special expedients had to be tried, with the view of lighting up the powder uniformly, or of causing the flame to spread quickly to all parts of the cartridge. The most successful of these expedients was to ignite the cartridge by a small charge of powder placed at the end of a species of conical open cage, which reached from the rear end of the cartridge up to about the centre. By this arrangement, which you here see represented (diagram), the fire from the vent is very quickly conveyed to the centre of the charge, and communicates through the open cage to the different parts of the cartridge.

I must still refer to another expedient, the result of careful reasoning and systematic experiment, which has been adopted with great advantage in regulating and equalising the pressures developed by the ignition of large charges of powder. This consists in so making up the cartridge that it shall not completely fill the space which it occupies in the gun, so that an air space is provided at the seat of the charge, into which the gases first developed from the powder expand, whereby the pressure at the commencement of the explosion, or the initial pressure, as it is termed, is relieved, and the accumulation of pressure consequently takes place more gradually. For if the pressure in the powder-chamber of the gun is comparatively low at starting, the further burning of the powder will take place more gradually, and the pressure will increase more uniformly than if a comparatively high pressure be at once produced, in consequence of the very small space which the gases are compelled to occupy at first, or of the powder presenting a very large inflaming surface, or of its surface being very rapidly inflammable. In providing the air space, of which I have endeavoured to make clear to you the advantage, the most convenient mode of proceeding is to make up the cartridge so much smaller in diameter than the bore or powder-chamber of the gun as is necessary for affording the desired total space in which is is desired to inflame the charge, the length of the latter being of course proportionately increased. The space might also be provided by leaving an interval between the cartridge and the base of the shot; but from what little I have said regarding the occasional production of severe local pressures in the gun, and from what many of you may have read in the public prints with regard to one possible explanation of the recent fearful calamity on board the *Thunderer*, you will be prepared to hear me say that it is only possible to have recourse to this mode of providing air space for the charge to a limited extent, without risk of submitting the gun to the distressing and possibly destructive action of a very sudden and violent local strain near the seat of the shot. For if a considerable interval exists between the charge and the projectile, the products of explosion rapidly generated from the powder will rush into this air space with so high a velocity that, upon being suddenly brought up by the projectile, which is still stationary, or has only commenced to move, they will strike a blow of enormous force upon the latter, and upon the part of the gun's bore immediately in rear of it. Remember, I am not speaking of this as the cause to which the bursting of the 38-ton gun on board the *Thunderer* is to be ascribed,* either wholly or in part, as all the circumstances attending that terrible accident are not yet thoroughly known to us, and perhaps never may be, sufficiently to throw proper light on the calamity. I only desire to point out that, in applying the expedient of air spaces for relieving the pressure developed upon the ignition of very large charges in guns, such an application might actually be productive of mischievous instead of beneficial results, if proper thought were not given to all points connected with the action of fired gunpowder in a confined space.

Before leaving the subject of the improvements recently effected in the ignition and the mode of burn-

* The lecture was delivered before the publication of the Report of the Committee.—Ed. *S. A. Journal.*

ng of large charges of powder in guns, I must briefly refer to a simple device which has been successfully elaborated with decidedly beneficial results, its effect being, on the one hand, to utilise more thoroughly the projectile effect of the force of exploding gunpowder, and, on the other, to protect the bore of the gun, especially that part situated immediately over the shot, from a kind of injury—sometimes by no means inconsiderable—caused by the enormously rapid rush of gas through the small space existing between the shot and the bore. The scoring, or so-called erosion, of the surface of the gun—due to the tearing away, and pushing one over the other, of the metal particles by the torrent of highly-heated powder products rushing through the very narrow space—has sometimes been so considerable as not simply to affect the accuracy of fire of the gun, but also to develop cavities in the metal, especially in the direction of the rifling, which might in time become serious sources of weakness.

This peculiarly-shaped disc of copper is one of the most efficient forms of so-called gas checks, which have been devised to protect guns from this kind of injury. When a disc of this kind is fixed to the base of the projectile, the first effect of the exploding charge is to bring the flange or broad rim of the disc into close contact all round with the surface of the gun, including that of the rifling, and thus effectually to prevent escape of gas past the shot, so that the scoring action is guarded against, while, at the same time, the force of the exploding powder is more thoroughly utilised.

And now, having endeavoured to give you some idea of the means employed, as the results of patient systematic investigation, for regulating, and at the same time utilising, more completely than formerly could be done, the explosive force of gunpowder when used in large charges, and in the form of the large fragments which I have described under the name of pebble powder, I have only to add a few words to this very long story, for the purpose of making you acquainted with the very latest modifications which gunpowder has undergone.

In order to test still further the effect of increase of the size of the masses upon the regularity of burning, and the maximum and mean pressures developed by very large charges, experiments were made in the Woolwich Infants, with gunpowder of considerably larger size than pebble powder, and the most satisfactory results, generally, were furnished by a dense powder, in the form of roughly-shaped cubes, with rounded edges, about 1½ in. in diameter. This powder, which is produced, like the smaller pebble, by breaking up large cakes of compressed powder of proper thickness into masses of the required size (but naturally of somewhat variable dimensions), now constitutes the service powder for our largest guns. It is of this powder that charges of from 400 lbs. to 425 lbs. are fired in our 80-ton guns, for the purpose of propelling shot 1,750 lbs. in weight.

But, although good results are furnished by this powder, we are not content to rest in our labours, but are aiming at further desirable improvements. Experiments have been made by us with even larger powders than our 1½-inch pebble, and it is not impossible that we may even come to build up our gigantic cartridges for the 80 and 100-ton guns of large slabs, of the full diameter of the cartridge; or there may be other directions in which we may be led to work, with prospects of fruitful results, than that of the variation of inflaming surface and density, with the object of increasing the power, while not interfering with the longevity, of our large guns.

And here I should state that while we have been active in the improvement of gunpowder, the Italians, who have been most intelligent artillerists from early days, and have of late devoted a large amount of scientific acumen as well as considerable resources to the development of the power of guns, have not been standing still in the matter of gunpowder. In fact they have been stealing a march upon us, for they have produced a powder—a modified form of our largest powder—which gives even better results than those we have as yet been able to obtain in our largest guns. By means of a new system of building up their masses of powder, they appear to have been very successful in attaining with it, in the first instance, comparatively slow action, followed up by a quick action of the charge, and a subsequent uniform sustainment of moderate pressure. In a recent trial, whereas 463 lb. of our large powder gave, with a 2,000 lb. shot, in the 100-ton gun, a velocity of about 1,600 feet, with a pressure of about 21 tons on the square inch, the Italians were able to use 110 lb. more of their new powder with the same weight of shot, imparting to the shot 100 feet more velocity than obtained with our powder, while the mean pressure in the gun was three tons per square inch below that which our powder developed.

Results a little superior to the best which have been furnished with the 80-ton gun by our large powder have, moreover, been recently obtained by us in a trial which we have made of the latest form used by the Germans, the prismatic powder to which I have already referred. If any incentive were required for continued exertions on our part for the improvement of gunpowder, it would be furnished by these evidences of the intelligent activity of, and of successes achieved in the same direction by, artillerists of other countries.

THE AGRICULTURAL PROSPECTS OF FIJI.

"Remarks on the Agricultural Prospects of Fiji" is the title of a little pamphlet by Mr. John Horn, of the Botanical-gardens, Mauritius, published at Levuka at the close of last year. In this pamphlet, Mr. Horn draws attention both to the staple products of Fiji, and to the plants suitable for cultivation for commercial purposes. The most important plant is, of course, the sugar-cane, and the suitability of climate and soil for a very large extension of the very valuable plant is fully pointed out. In Fiji, Mr. Horn says there is a very large extent of land, which, from a variety of causes, is better adapted for growing coffee than any other tropical product; next to sugar-cane, coffee will, no doubt, in future years, claim a large share of attention.

Regarding the cocoanut trees, with which it is known the Fiji Islands abound, Mr. Horne says: "Many of the cocoanut groves or plantations are much neglected, and allowed to be overgrown by scrub and climbers. Some of these groves belong to settlers, but most of them to the Fijians. The manner of clearing them is a reprehensible one, climbers are not only cut off the young trees, but generally the leaves to which they cling are taken away with them. When the weeding (clearing away the climbers, cutting the scrub and grass which surround and choke the growth) is completed, the rubbish is set on fire among the trees where it may be lying. This is at once an easy, simple, and effectual means of getting rid of it, and were the trees not injured by the fire to the extent of stopping their growth for a few years, it might be recommended.

Amongst plants likely to thrive and prove advantageous commercially, the cocoa (*Theobroma cacao*) is mentioned. Very few cocoa plants at present exist in the islands, and those that are thriving have not yet arrived at an age to bear fruits. The principal reason why the plant is not more cultivated is said to be owing to the difficulty and expense of procuring a sufficient number of young plants to make a fair trial. The advantages that would accrue from the establishment of a Botanical-garden in the colony, is illustrated by the fact that the various economic plants for experiments would be more easily obtained, and, consequently, more persevering efforts made to establish them. Tea, cinchona, and tobacco are, amongst other staples, recommended, as well as the clove, ginger, cinnamon, nutmeg, allspice, pepper, camphor, and vanilla, besides

most of the tropical fruits, such as mango, mangosteen, custard apple, tamarind, litchee, &c. With all the contemplated and looked-for cultivation of the Fiji Islands, and the knowledge that many of the native woods are excellent for their durability, and, consequently, useful for cabinet and building purposes, it is to be hoped that ere long a very large traffic will be opened up with Fiji.

HEALTH IN THE HOUSE, AND FOOD AND HOME COOKERY.

Two little books, written for the purpose of raising the standard of the working classes by diffusing a knowledge of the laws of health, and in profitable and practical cookery, have recently been issued by Messrs. Longmans. The first, which in reality is a new edition (the ninth), is entitled "Health in the House," and embodies the substance of a course of lectures "on elementary physiology in its application to the daily wants of man and animals," delivered to the wives and children of working men in Leeds and Saltaire. The second volume is "Food and Home Cookery, a course of instruction in practical cookery and cleaning, for children in elementary schools, as followed in the schools of the Leeds School Board." The lectures are written in quite plain language, suitable, we are reminded, to the understanding of artisan children from the ages of ten to thirteen. During the whole course of the twenty-five lectures on the laws of health, which extended apparently over a period of five months, the average attendance was fifty; with only one exception the children were most attentive, and looked forward to the lectures with pleasure, and from the answers sent in by the pupils it was evident that the information given was fully understood. Equal success attended the same course given by the lecturer to the work-people of Mr. Titus Salt, at Saltaire, the audiences being composed of an average of four to five hundred working women and their daughters. The success which attended these lectures was, no doubt, due to their simplicity and the anecdotal illustrations interspersed through them, two points that should be borne in mind by all whose mission it is to explain scientific matters to an untrained audience.

Regarding Mrs. Buckton's book on "Food and Home Cookery," there can be no doubt that its extensive distribution among the poorer classes would effect much good both in economy, efficiency of diet, and clothing; much indeed may be learnt from it by those who are supposed to know all about these things.

CORRESPONDENCE.

CAUSES OF DEPRESSION IN TRADE.

The magnitude of the question "On the Causes of the Present Depression in Trade," so ably introduced in the paper read by Mr. B. Francis Cobb, and so pertinently discussed by Mr. Cassels, Mr. Bourne, and others on Wednesday last, induces me to hope that this discussion may be the precursor of a Conference, to be inaugurated by our Society, upon this important subject. The limited time at the disposal of the meeting was, no doubt, the reason for many of the vital causes of depression not having been mentioned, and the members would, I am sure, not wish the public to think that they had wilfully overlooked such reasons. It appears to me that the root of the evil is to be found—

Firstly. In the disregard by the State and the public of the ordinary laws of supply and demand.

Secondly. In the extravagance and indifference to results, alike of the Government and the people.

Thirdly. In deficient harvests, whether of food or of gold, and natural causes, over which the people have but partial or no control.

The first cause is particularly exemplified in the fact that our merchants and manufacturers invest nearly all their energy and capital, and our artisans all their labour, in producing a "supply" of material and manufactures, without, at the same time, opening up new channels, at home and abroad, of "demand" to keep pace therewith. This "supply" very properly grows with our growth; but the "demand" must grow in like ratio, or, as with the Siamese twins, the death of the one will cause that of the other.

The sources of demand are illimitable. Our colonies and possessions, and many foreign countries, are crying for railways, harbours, immigrants, &c., &c., and we cannot disregard the demand any longer.

At the present time the supply of shipping is enormously in excess of the demand, still steam-ship building is going on almost, if not quite, as briskly as ever.

The shipowners have lost money in nearly every case during the past two years. They are losing more now than ever. The rates of freight are lower than ever known to the present generation, and still have a downward tendency, because the prices of nearly all imports and exports leave no profit whatever. Either the supply must be stopped or a new demand must be created. But the supply cannot be stopped without clogging the ever revolving wheel of industry; therefore the demand must be created.

As contributing to the second cause, may be mentioned the extravagance of our Governments in their continually increasing expenditure upon war, the army and navy, their frequent embroilments with other nations, the sinecure offices and emoluments created, and the consequent absorption of the country's capital and labour in nonproductive channels. Also the extravagance and indifference of the people in wasting such enormous sums in drink and other pernicious items, including loans to insolvent foreign Governments.

The incidence of taxation and the evolution of exchanges are also secondary subjects which may, and do, contribute greatly to financial crises and embarrassments, but scarcely come within the catagory of primary causes of the depression in trade. Lieut. Armit may rest assured that, whether the people favour "producers" or "consumers" in theory, they will always go to the cheapest market, and that, however much they may sympathise with the sugar refiners of this country, they will rejoice at the suicidal "bounty" system of the French Government which enables them to buy cheaper sugar. Nor will any Government make us pay so much for the corn we require to import from foreign countries to stimulate exports from our colonies. Trade, like mankind, must be free, and that which having freedom still cannot live, must, according to all laws of nature and humanity, perish.

W. Mead Corner.

105, Leadenhall-street, London, E.C.,
6th April, 1879.

PRESERVATION OF IRON FROM RUST.

A short absence on the Continent has prevented me from sooner writing you on the subject of Professor Barff's paper, read by that gentleman before the members of the Society of Arts, on Wednesday, the 26th of March, on "The Treatment of Iron to Prevent Corrosion."

Professor Abel mentioned the fact that thero was my air as well as a water process of producing magnetic oxide as a coating for the preservation of iron from rust; and I must confess, from the extreme friendliness of all the communications which have passed between Professor Barff and myself, that I did not expect to see

remarks he is represented to have made, viz.:—"That Mr. Bower had seen his process and then devised a scheme of his own, and then wrote and suggested that they should join." Now this implies most ungentlemanly conduct on my part, that what I patented was the result of the information I managed to extract from the Professor.

Now, it is on record in the pages of the Society's *Journal* in a letter of mine, and published therein about two years ago, that, but for an accident, I should have forestalled the Professor in his discovery.

To that letter I had a very courteous communication from Mr. Barff, thanking me for the generosity of my remarks; but it is an undoubted fact that, on reading the paper in which he announced his discovery, I instantly conceived the idea that what the Professor could do with the oxygen in water might also be done with the oxygen in air, even though one was chemically combined, and the other only mechanically mixed.

In order to clear myself of the somewhat odious inference the Professor's remarks imply, I wish to relate a circumstance, and for which I claim some credit, for the prescience of my conception. I had received an invitation from the Professor to see his process at Kilburn and to luncheon with him, which I gladly accepted; but, having already conceived the idea of using air as the oxidising agent, I took the precaution to mention to three gentlemen who were dining with me, that as I was going to see Professor Barff, I thought it possible that at some time or other it might be said of me if I took out patents after I had visited him, that I had "devised a scheme" out of the Professor's brains, and that therefore I particularly desired them to bear in mind that Mr. Barff claimed "water," while I should claim "air." I can only recollect two of the gentlemen who dined with me on that occasion, and I give their names and addresses:—Charles Robert Wade-Gery, Esq., solicitor, St. Neots; and the Rev. Henry L'Estrange Ewen, Rector of Offord D'Arcy, Huntingdon. I trust I have disposed of the rather unpleasant imputation which but for this explanation would have attached to me. To show that I was on the same line as the Professor ten years ago, before he obtained his patent, I have only to refer your readers to my letter inserted in the *Journal* the end of March, 1877. I missed the oxygen in water but I hit that in air, and I am well satisfied with it.

I now crave permission to dwell for a short time upon the general subject of the protection of iron from rust by a film of magnetic oxide.

Professor Barff not only expatiates upon his own process, and seems rather to complain that business men do not adopt it, but he is somewhat careful to give a rather ungenerous blow at the air process. Now, I am quite ready to admit, as I have always done, and I hope I ever shall, that the utmost merit is due to the Professor for his discovery, and he deserves to reap the reward of it; but let me also have a niche in the Temple of Fame. I only ask a very small one, and, though I lay no claim to a tithe of the scientific knowledge of Professor Barff, yet I am able to speak of that which I know; and, if I am inconveniently in the way of those who are associated with him in the business, they must consider that no man can monopolise the whole field of discovery, and that there is rarely one great invention which does not beget another of a similar nature.

Like the Professor, I was in too great a hurry in sending out specimens of my process; but, like him, I may now say, after two years of continuous experiment by myself and my son, that we are now in a position to practically undertake the coating of articles by my process and by another one patented by both of us.

The Professor may not have succeeded with air, but there is the possibility that he did not wish to do so. All I can say is, that I now produce as perfect specimens of coating on cast iron as it is possible for any to be, and I have some which have been exposed now close upon two years in my garden, which are as perfect as ever. One is a square bar of cast iron, which was subjected to the action of a current of heated air at the blast furnaces of Messrs. Cochrane, of Dudley, in July, 1877, and which is free from rust, except where the bar was cut in two after it had been treated. The Professor and myself have both of us, I dare say, found by experience in our experiments the truth of our school-day copy-book writing lesson, "Trust not to appearances," for it frequently happened during my experiments that the appearance of the articles was beautiful, but that the oxidation had not been sufficiently prolonged. I had a specimen of Mr. Barff's which did not stand, but this would only be the failure of a particular experiment, leading up to that perfect knowledge which enables both of us to say that we are now ready to put our processes in the market. The French Government have adopted my air process for what they call "bronzing" the barrels of their rifles, and Captain Bourdon reports that it answers admirably. I am now about to treat 20 to 30 tons of stable fittings, and, having completed very costly experiments, the process will, I hope, be speedily employed in the practical application of it to ordinary articles for commercial purposes. Professor Barff almost ridicules the idea of being able to say at what rate per ton iron work can be coated, but until we are in a position to do so, we can not expect the trade to take up with either of our processes. For my own part, having large engineering works, and being a practical man, I am in a position to say definitely the cost per ton, and with my process it is really not more costly whether with a lump of a ton weight or applied to a thousand articles of the most intricate forms of the same weight, save and except in the labour of placing them in and taking them out of the chambers. The absolute cost of the treatment will not exceed two pounds sterling per ton by my process.

I am a little surprised at Mr. Barff attempting to attribute the formation of black oxide to the moisture which might be contained in air, if it were first put into a holder floating in a tank of water; but I do not use air from a holder, I only take such as nature supplies, and which contains all the oxygen that I require for my purpose. It is rather going beyond the mark to ignore the 22 per cent. of oxygen in air, and value it at *nil* for this special purpose, when it is active enough in its normal condition to produce on iron the sesqui-oxide.

In conclusion, I would desire further to say that I trust I have said nothing in disparagement of the Professor's great discovery; and if I have hit upon a simpler and cheaper method of producing the same result, I am only anxious to defend my own process, if it be either directly or indirectly attacked. There is room enough for both Professor Barff and myself, and he shall find in me (if it must be so) a friendly competitor.

George Bower.

St. Neots, Hunts., 7th April, 1879.

P.S.—I have pleasure in sending a few specimens to the Society of Arts for any member to see who may be so disposed.

NOTES ON BOOKS.

Summary of English History. By Llewelyn C. Burt. London: Simpkin and Marshall.

This is a short summary of the principal events in English history, arranged in chronological order, and in a tabular form, for the use of schools. It is intended to form a sort of groundwork, to be afterwards filled in from manuals of a more elaborate character. Genea-

logical tables are also given, and much supplementary information is supplied in the form of notes. The book is also illustrated with a coloured map of France in the reign of Henry II., A.D. 1154.

GENERAL NOTES.

The Ice Crop of the Hudson.—This year the ice crop of the Upper Mississippi is reported very great, and the same is true of other northern rivers from Minnesota to Maine; but the probability is that more ice is taken from the Hudson than from any other stream or body of water, not only in the United States, but in all the world. The harvest this year has been the most successful ever known, both as regards quantity and quality. The total capacity of the ice-houses along the Hudson exceeds 2,000,000 tons. These have been filled to overflowing with ice of the finest kind, and upwards of a million tons in addition have been stocked for early consumption. During the gathering time over 10,000 men, nearly 2,000 boys, 900 horses, and 100 steam-engines, were employed in getting in the crop. The pay of the harvesters has ranged from 1 dollar to 1·75 dollar a day. The season began the first week in January, and continued throughout the month.

NOTICES.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

April 23.—"English Fresh-water Fisheries." By J. Willis-Bund, Esq., Chairman of the Severn Fishery Board. Francis T. Buckland, Esq., M.A.., H.M. Inspector of Salmon Fisheries, will preside.

April 30.—Renewed Discussion on Mr. John Hollway's paper (read February 12) on "A New Process in Metallurgy." Prof. H. E. Roscoe, F.R.S., will preside.

African Section.

Tuesday Evenings, at Eight o'clock.

April 29.—1. "Light Railways for Opening-up a Trade with Central Africa," by John B. Fell, Esq.; and, 2. "The Advantage of Railway Communication in Africa, as compared with any other Mode of Transport," by J. Conyers Morrell, Esq. Captain Sir Henry Tyler will preside.

May 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

Chemical Section.

Thursday Evenings, at Eight o'clock.

May 8.—"The History of Alizarine and Allied Colouring Matters, and their production from Coal Tar." By W. H. Perkin, Esq., F.R.S.

May 15.—Continuation of Mr. Perkin's paper.

Indian Section.

Friday Evenings, at Eight o'clock.

May 2.—"The Wild Silks of India, especially Tussah." By Thomas Wardle, Esq. Sir P. Cunliffe Owen, C.B., K.C.M.G., will preside.

Cantor Lectures.

Third Course, by W. H. Preece, Esq., on "Recent Advances in Telegraphy."

Lecture I.—April 21.

Definitions of telegraphy and electricity. Electrical effects. Sources of electricity. Economical distribution of electric currents.

Lecture II.—April 28.

The transference of electricity. Wires. Insulators. Supports. Gutta-percha, india-rubber. Underground wires and cables.

Lecture III.—May 5.

Simple telegraphy. Visual and aural signals. Telephones. Telegraphic writing.

Lecture IV.—May 12.

Duplex, quadruplex, multiplex, and harmonic telegraphy.

Lecture V.—May 19.

Automatic and fast-speed telegraphy.

Members can admit TWO friends to each of the Ordinary and Sectional Meetings, and ONE friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Tues. ...Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m.

Statistical, Somerset-house-terrace, Strand, W.C., 7¾ p.m.

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Wed. ...Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Resumed Discussion on the Rev. W. Clement Ley's Paper, "The Inclination of the Axes of Cyclones." 2. Mr. G. M. Whipple, "The Results of Comparisons of Goldschmid's Aneroids." 3. Mr. P. F. Reinsch, "Observations on the Temperature of the Atlantic during the Month of March."

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. H. Syer Cuming, "Easter Eggs." 2. Mr. C. W. Dymond, "The Hurlers, Cornwall."

Thur. ...Linnean, Burlington-house, W., 8 p.m.

Chemical, Burlington-house, W., 8 p.m. 1. Mr. J. B. Grosjean, "The Determination of Tartaric Acid in Lees and Inferior Argol, with some Remarks upon Filtration and Precipitation." 2. Mr. M. M. P. Muir, "Conditions affecting the Equilibrium of certain Chemical Systems."

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

Royal Society Club, Willis's-rooms, St. James's, S.W. 6 p.m.

Philosophical Club, Willis's-rooms, St. James's, S.W., 6½ p.m.

Mathematical, 22, Albemarle-street, W., 8 p.m.

Psychological, 11, Chandos-street, W., 8½ p.m.

Civil and Mechanical Engineers, 7, Westminster-chambers, S.W., 7 p.m.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

CHEMICAL SECTION.

Thursday, March 27th. Dr. W. J. Russell, F.R.S., in the chair.

The paper read was—

THE INOXIDATION OF IRON, AND THE COATING OF METALS AND OTHER SURFACES WITH PLATINUM, BY THE PROCESSES OF MONS. DODÉ.

By L. M. Stoffel, C.E.

The origin of the patented processes, about to be described, for the inoxidation of iron, the enamelling of metals, and the platinum coating of metals, arose, incidentally, out of the researches in which M. Dodé had long been engaged, for the application of chloride of platinum to the silvering of glass, in a form that should supersede the deleterious mercurial processes in common use.

Although the title of the present paper contains reference to the platinising of glass and other substances, it is intended, on this occasion, solely to confine the description of M. Dodé's inventions to their application to metal surfaces. At some later period an opportunity may be afforded of treating, in another paper, the bearing of two of the processes concerned in the treatment of glass, whether in form of sheets or tubes, or of blown or moulded objects, and also of ceramic ware.

The problem of the inoxidation of iron, or, in other words, of the permanent preservation of that most useful of metals from the attacks of rust, has long occupied attention. The possible utilisation for this purpose of platinum—a metal possessing the qualities of being entirely unaffected by atmospheric changes—has not escaped research. Nevertheless, none of the attempts hitherto made in this direction can be said to have led to a practical result, or one applicable to manufacturing purposes. The two latest of these, namely, those of Professor Barff and Mr. Bower, depend upon the production of a superficial coating of magnetic oxide; and, however excellent in their way, can scarcely be termed ornamental. When any other colour than bluish-grey is required, they are inapplicable, and the material has to be painted in the ordinary way.

Hitherto, the rendering of metallic objects impermeable to rust, has been partially accomplished by means of electro-plating—a lengthy, costly, and in many cases inapplicable method. Iron, for instance, cannot be electro-silvered without an intermediate coating of copper. Moreover, cast-iron articles placed in an acid bath as a preparatory step to being subjected to galvanic action, have their fibre irretrievably deteriorated. The first action of the acids employed in the ordinary galvanic process is actually to form a coating of the objectionable oxide or rust upon the surface treated. On this the metal to be applied deposits itself. But the layer of oxide beneath the outer covering of metal is never entirely got rid of. It is always liable to affect the outer surface of the object coated, as may be frequently observed in galvanised iron, and in all cases the coating of deposited metal has to be of a sufficient thickness to counteract the spontaneous oxidation primarily due to the acid used in the galvanic process.

It seems to have been reserved for M. Dodé, a French chemist of repute, whose family have for several generations actively devoted themselves to metallurgical research, to perfect and patent processes successfully solving the two-fold problem of the inoxidation of iron and the application of platinum to its surface in a practical and inexpensive manner.

The first process, "inoxidation of iron," consists in coating, either by means of a bath or a brush, any objects in cast or wrought iron (freed from the damp they may contain) with a composition consisting of borate of lead, oxide of copper, and spirits of turpentine. This application soon dries on the surface of the iron, and the objects are then passed through a furnace, which is heated from 500 deg. to 700 deg. Fahr., according to the thickness of the articles under treatment, so as to bring them to a cherry heat when passing through the centre of the furnace. At this point, the fusion of the metallic pigment takes place; it enters the pores of the iron, and becomes homogeneously adherent thereto; covering the objects with a dark colour, not liable to change through atmospheric, gaseous, alkaline or other influences, nor to disintegrate from the surfaces to which it has been applied. When any considerable depth of inoxidation is desired, the object may be immersed in the composition for the time requisite to absorb a sufficient quantity thereof. Corrugated iron may be treated by means of the above described coating, which supersedes galvanising, is of lesser cost, and is produceable in several hues of dark colour. This first process wholly supersedes painting and varnishing, and metallic objects thus treated are rendered impervious to rust, and hence are of much greater durability. The cost of application is computed at an average of ¼d. per superficial square foot.

The second process, "enamelling of metals," consists in a repetition of the coating operation, but with a pigment differing from that above described, and having for its object the production of a smooth polished surface, such as is obtained with thick enamels. This pigment, which is composed of borate of lead, litharge and essence of lavender, may be applied directly upon metal, and it renders iron also inoxidisable, although not to such a degree of perfection as when preceded by the first pro-

cess. Its object is to supersede enamels, which it does most advantageously, with respect to cost and durability, while furnishing a smooth and even surface for receiving and effectually protecting the subsequent economical application of platinum or gold to articles thus treated. An extensive variety of coloured enamels may be produced, separately or in combination. The cost of this process is computed at 1d. to 1½d. per square foot superficial.

The third process, "platinum coating of metals," is applicable to both of the inoxidating and the enamelling processes, but with this difference of result:—In the first case the platinum yields the appearance of dull silver, and in the second it resembles this metal so highly burnished as to render any subsequent polishing wholly unnecessary. The dry chloride of platinum dissolved in ether, and held in solution by essential oils, is simply applied by means of a painter's brush or a bath, according to the ornamental effects desired, and by the simple aid of heat sufficient to cause the evaporation of the medium which holds the platinum in solution, a heat not exceeding 350 to 400 deg. Fahr., the platinum becomes incorporated with the inoxidated surfaces. The result is, that a relatively infinitesimal portion of platinum suffices to coat a considerable surface; while this metal, being unaffected by atmospheric variations or by the products of combustion of gas, objects treated by M. Dodé's inventions are rendered unalterable by exposure, or by ordinary wear and tear. The cost of this last process varies from 1d. to 3d. per square foot superficial, according to the thickness of the metallic coating applied. When it is desired to produce a highly brilliant surface, two successive coats of the preparatory enamelling are given, and an increased quantity of the platinum solution is applied. Gold, similarly prepared, may be used in lieu of, or in combination with, platinum, at considerably less cost than when employed for electro or leaf gilding. In the case of platinising or gilding objects of polished metal, the first coating may be entirely dispensed with. No burnishing is required in order to produce a bright surface with this process.

With reference to the various degrees of heat which are essential to the successful application of M. Dodé's process, it is necessary to remark that, as the metal objects subjected to treatment are heated and cooled gradually by special furnace arrangements, and as the maximum duration of exposure to the greatest heat does not exceed five or six minutes, no detrimental effect whatever can possibly ensue.

By M. Dodé's processes, which substitute heat for galvanism, the use of acid is entirely dispensed with, and, there being thus no cause to encourage oxidation, no obstacle is offered to the instantaneous amalgamation of the original surface with the applied metal; a sufficient degree of heat only is required to cause the evaporation of the substances by which the latter are held in solution and fusion. The merit of the discovery lies in the method of preparing and holding the various metallic pigments in solution, and in directly applying them to the objects under treatment, with no other aid than such degrees of heat as do not affect the condition of the metals treated. Compared with electro-plating and galvanising, these processes, by reason of their moderate cost and the facility of their application, present such advantageous features that a large field for operation is thereby opened.

In fact the field offered in the industrial world for the practical application of M. Dodé's inventions may fairly be described as boundless. There is hardly any limit to the application of the processes save the size of the furnace, and hence they can be applied with equal facility, and by common mechanical means, to a metal paper-weight or a pillar letter-box, to a door-knob or to a park-gate.

By the black or inoxidating process objects are rendered durable, by the enamelling and the platinising processes absolutely beautiful, and at the same time impervious to the effects of outdoor exposure. It is not too far, perhaps, to look forward to the day when galvanised iron roofs and buildings, in their grey unsightliness, will be replaced by sheets of softly glittering metal, pleasantly refreshing rather than dazzling to the eye, when lamp-posts, converted into gleaming pillars of silver, or gold, or bronze, shall reflect the lustre of the flame they support, and when pillar letter-boxes, street orderly bins, and metal corner posts shall combine the useful with the attractive. Iron railings, too, around public monuments and building, such as the British Museum, instead of requiring continual coats of paint, or having their spikes periodically covered with gold leaf at a great expense, compared with the effect and durability obtained, may be advantageously treated by M. Dodé's invention; for he contends that by the substitution of gold for platinum as the outer coating in his process, he can produce the effect of gilding at one-twentieth of the cost where gold leaf is employed, and obtain at the same time an infinitely greater durability. Here is an opportunity for the City or Cathedral authorities to venture upon an experiment which deserves trying. The railings round St. Paul's Cathedral are to be redecorated, simultaneously with the improvement of the churchyard. Instead of adopting the present expensive method of gilding, why not coat them with M. Dodé's composition, at considerable saving in the cost?

In all cases cost is a most important feature of preservative operations, and it it may be broadly stated, in reference to M. Dodé's method, that the cost of platinising is about equal to that of applying three coats of paint, and about one-tenth of that of electro-plating with nickel. These comparisons have reference to Paris prices, which, as a usual rule, are not lower than English. A detailed account of the treatment of eight stoves, one of which is now exhibited to this meeting, is as follows:—

	Frs.
1 litre preparation (retail)	3·75
First furnace operation	3·20
Reagents for platinising	4·00
Second furnace operation	3·30
Manipulation, wear and tear, &c.......	1·85
	16·10

being 2 francs, or 1s. 8d. per stove. The French trade is quite willing to pay four times this rate, as to nickel-plate, a similar stove costs from 30 francs to 40 francs; and the Val d'Osne Company, who are large manufacturers of these stoves, have expressed a highly favourable opinion of the results arrived at.

The preservation of iron ships from the action of salt water by means of M. Dodé's invention is a problem as yet requiring further investigation. But so far as a ship's numerous fittings, now made in brass or galvanised iron, are concerned, there can be no doubt of the superior strength and durability of metal treated according to his patent, and there would be no comparison between the strength of galvanised and platinised iron-wire for standing rigging. The insulation and preservation of telegraph wires, and the preservation of the iron-work portions of railway rolling stock, also deserve attention.

M. Dodé may, at least, be congratulated upon having successfully solved a problem that has been for a long time occupying the attention of the iron trade, namely, the opening up of a fresh field for the employment of wrought and cast iron. Ordinary cast or wrought iron preserved and decorated at a trivial cost, according to his methods, will replace, to a considerable extent, copper, nickel, brass, and other costly metallic substances hitherto employed. Large foundries devoted to the production of ornamental metal work are likely to accord an unfeigned welcome to a discovery which will enable them to preserve their manufactures from rust, obviate all necessity for periodical polishing whilst the articles remain in stock, and also enhance their appearance and, consequently, their value.

Articles of common use, and ornamental productions of high class, can be advantageously subjected to Mr. Dodé's processes at very moderate cost; while the market value of all objects treated is considerably enhanced, not only through their highly ornamental appearance, but also by reason of their non-liability to corrosion.

In concluding this brief explanation of the various advantages presented by M. Dodé's discoveries in metallurgy, it is only necessary to call attention to the various specimens exhibited this evening, and to state that, M. Dodé being present, it will afford him much pleasure to explain any matters of detail, or to answer any questions bearing upon practical applications of his inventions.

DISCUSSION.

The Chairman said he should like to know whether both processes mentioned, namely, the first one, by which the substance was covered with borate of lead, oxide of copper, and turpentine, and the other, in which borate of lead, oxide of lead, and essential oil of lavender were used, were necessary before the application of the tetrachloride of platinum.

Mr. Stoffel said the first process was applied simply when the iron was desired to be protected against oxidation, and the colour was dark. If the second process was desired, its object was to coat the iron with enamel, which would give you two or three dark colours; it was principally devised so as to form a proper recipient for the coating of platinum. Without this process, the quantity of platinum required to cover the iron would be considerable, but when it was used, the quantity required was infinitesimal.

The Chairman said he understood that they did not platinise on the first process; but the second was employed when platinum was to be used afterwards.

Mr. Stoffel said that was so. They could apply platinum on the first process when a polished surface was not desired; but when a bright surface was required, you must use the second process.

M. Dode, who spoke in French, gave a brief sketch of the experiments which had led him to develop this process. He had first sought to substitute platinum for mercury in the making of looking-glasses, of which he had made a considerable number, and specimens of which he exhibited. His factory being destroyed at the time of the war, he turned his attention to the coating of metals with platinum, and especially to avoiding that oxidation of the metal to be coated, which took place in the galvanic process by the action of the acid on the surface before the deposition of the metal, the consequence of which was there was no solidity in the work. After many experiments, he succeeded in dissolving the platinum to the state which he showed in a small phial bottle, containing 7 grammes of platinum, and which he said was sufficient to platinise more than twice all the articles exhibited.

Mr. Spencer said he had heard of this invention within the last fortnight or three weeks, and having in earlier life tried to effect the same end, he felt a great interest in it. At first he was rather disposed to doubt, not that with essential oils a coating of platinum could be given to many things, because he had already tried it, and it had been done with regard to china, producing the article formerly known as lustre ware, which was made at Tunstall in Staffordshire, a piece of which he produced. As far as he understood, it was applied in much the same way, but it had not been applied to metals. He had himself applied it to metals, but not in the same way as this. He applied it to lead in order to get a negative galvanic plate for a battery, for which, many years ago, he took out a patent. When he heard of its being applied to iron in the same way which had been shown, he asked a friend who knew Mr. Stoffel to get him a bit of it, because he rather doubted whether it would stand. He had, however, put it to some very severe tests, and it stood in a way he did not expect. He must, however, say, there were some few pin-holes of a trifling character; but he was convinced that a double coating would produce such a protection to iron as had never been seen yet. He said this, having made many experiments in early life upon the subject, in the introduction of electrotyping. It was then a problem with him to coat iron with copper electrically, and he had succeeded, but only to a certain extent. It was not done with facility, and the iron had to be prepared very carefully in the first instance. Even then it was never a thing which could be largely adopted in practice, because there was so much trouble in getting rid of rust in the first place, and then there was a want of adherence between the two metals. He was, therefore, delighted to see the problem solved so simply. But as he was informed the iron was subjected, after the iron had been coated, to a cherry red heat, which meant something like 800° or 850°, there were some metals which could not be subjected to that heat with impunity. He had been often struck with the great many affinities between iron and platinum. In the first instance they were two weldable metals *par excellence*. He also found in making experiments that adherence took place between them at certain heats, and that when this was achieved it would remain. The colour of these specimens was not the true platinum colour, which showed him that the surface of the iron and platinum had amalgamated, because platinum and iron would form an alloy. No one probably would think of using platinum for looking-glasses if they could get silver or quicksilver, because the colour was not so good. You might not notice it immediately, but a lady dressing for a ball would not like the cadaverous look it would impart to her countenance. It was now found that, by a new process, real silver could be deposited on glass by the aid of essential oils; but, in practice, it was very seldom they did not find defects here and there, where the essential oil had not been thoroughly removed. In fact, looking-glass makers told him that they could depend on nothing but the old

mercurial process, which was not now open to the same objections as formerly. With regard to the covering of iron, it seemed to him one of the most valuable discoveries ever brought before the Society; and, having had a great deal of experience, he must say he knew of nothing which came up to what he now saw. This process would do an immense deal for both the industrial and fine arts. He should hardly imagine that a vessel of wrought iron, if coated in that way, would stand the action of acid like a platinum vessel, but it would do an immense deal in other respects. He believed it would keep intact for ages as far as the influence of the atmosphere went, and, looking at the perfection now attained in iron casting, there was no reason why it should not be largely employed in artistic work. Some of the Berlin castings were as fine and beautiful as anything you could imagine in plaster of Paris; but the reason they were not used in public statues was that the iron was subject to rust, and when they were painted all their beauty was gone. By this process he could imagine almost every statue being made of iron instead of bronze, and it would not be subject even to the drawbacks to which bronze was in this country out of doors, being turned green, black, and other colours by oxidation. For statuary purposes two coatings might be given if necessary, and it might be done at once before even the metal got cool from the castings.

Mr. Silk asked what was the cost of this process as compared with Mr. Barff's process, described the previous evening; what was the heat required for the inoxidation process; if the iron required any previous manipulation; and whether brass and other metals could be platinised.

Mr. Stoffel said he was not aware of Professor Barff's estimate, but the ordinary price of inoxidation was one farthing per square foot. That was the price actually arrived at on a small scale, and would most probably be diminished when working commercially. The treatment was regulated by the thickness of the iron. It had to be raised to a cherry red heat so that the oils might be evaporated and the pigments become melted and be imbedded in the iron. According to the thickness of the iron so was the heat required, varying from 400° to 1,000°. The iron required no previous manipulation except to thoroughly dry it. The principal use of the first pigments was to prepare the surface to receive the platinum, but on polished steel or German metal the platinum might be applied direct, and would adhere with a less degree of heat.

Mr. Raper said any Englishman returning from abroad was generally struck with the peculiarly dull, unhandsome appearance of the buildings in comparison with what he had been accustomed to on the Continent, and no doubt it had occurred to many that it would be most desirable if the inelegant appearance of our houses could be improved, all their conditions of stability and durability being preserved. He had no anticipation that this invention would supersede the galvanising process for some purposes, but there were no doubt many applications for which the latter would not be suitable, and one of those would be to cover the outside of buildings generally with thin plates of iron coated with platinum, and in certain forms of decoration. It also might be adapted to the interior of rooms. The ornamental appearance of the glazed ware about the buildings of South Kensington and the Albert-hall might have struck many people. Encaustic tiles were capable of a large amount of beauty and immense solidity, but they were far too expensive for general adoption. There was a process, however, which might be adapted to many ornamental purposes of that character with great advantage. Such thin plates of iron might be stamped in any ornamental design or even colour He had always understood that metals were opaque, but he noticed that one sheet of glass which had been handed round coated with platinum could be seen through, showing that the coating must be exceedingly thin. The advantage of these thin plates of iron would be that they would not be breakable, and they would not affect any rain water passing over them. The idea of introducing platinum, one of the most expensive of metals, on such a wholesale scale as this, struck him as certainly a most daring idea, and reminded him of the old motto, *audaces fortuna juvat*.

Mr. Edward Spon said it appeared rather invidious to criticise an invention with such beautiful examples exhibited, and it certainly did not require much consideration to understand the value of any process by which platinum could be applied in extremely thin films impervious to acid and oxidisation; and any man who could do it would realise a large fortune. He confessed a doubt whether this invention in its present stage would resist oxidation or acids. It was not at all a new thing that metals mixed in some form with essential oils would form a coating on other metals. Cooley's "Cyclopædia of Receipts" had about twelve or fourteen receipts for this operation, all of which he had tried, and they were all more or less defective. In one of them, bichloride of platinum, or bichloride of gold, was dissolved in tannic acid, which produced very easily a coating of platinum on brass; but, as far as his observations went, it would not touch iron. He had been through M. Dodé's experiment, as far as he could on a laboratory scale, but could never get a bit of iron sufficiently coated to resist the action of the atmosphere. Mr. Spencer had spoken of pin-holes, and all his deposits had been streaked. The heat to which the articles were subjected would certainly seriously affect any small article of iron or steel. He could not see any description of the process in the paper, but, as far as he understood, the action of the essential oil was to precipitate the metal in a finely divided state; but the heat that the article was subjected to afterwards would certainly not fuse the platinum sufficiently to make a thin coating; and, if it was only thrown down in a powdered state, it must inevitably have interstices, however small, which would be open to the action of acids or oxygen. He also doubted whether M. Dodé would not find the expense considerably more than he anticipated, because nearly all the articles used were of a very expensive nature. Perhaps some other essential oil might be found to replace the oil of lavender; the oil of lavender, of the quality necessary to be used in the process, would cost, in England at least, £4 5s. to £5 per fluid ounce. The Continental oils of Spike, which were used to replace oil of lavender, were very cheap, viz., 3s. to 5s. per lb., but they were totally useless, and as far as he could ascertain, the ordinary English oil of lavender was also worthless. He should like to know if the operation of burnishing was required, because it was very expensive on platinum.

Dr. Lempriere regretted that it was not in his power to deal with this question from either a scientific or a commercial point of view. The only point to which he would address himself was the enormous advantage which would arise from this process to ordinary householders. Some observations had been made by Mr. Spon, but the answer was a simple one of fact; Mr. Spon had not succeeded, and M. Dodé had. With regard to the other question, about the streakiness and the spots, he looked upon it solely as a practical man of common sense. He had been present at almost all the experiments made by some of the best scientific men of England, some of them conducted at Messrs. Johnson, Matthey, and Co.'s, in the presence of some 30 gentlemen, who were picked out as being of great eminence in connection with metallurgy. The experiments conducted in Mr. Matthey's office, before these gentlemen, did not show a single failure. Mr. Spencer—than whom there could be no greater authority on the question of metal-plating—

had told them there might be certain small pin-holes, after subjecting these specimens to, perhaps, the severest chemical test known, but yet, by a second coating, all danger from these pin-holes could be obviated. There were many questions it would be presumption for him to touch upon, but he could not help remarking what an enormous advantage the application of such a simple and inexpensive process would be to common domestic use. Every day iron was being used more and more for the utensils of the house; almost every part of our houses were being improved by a more easy and cheaper appliance of iron. The water-pipes which carried off the rainfall were a source of constant expense, from the enormous oxidation that occurred, sometimes going so far that they actually rotted away at the ends; but if, by this process, they could be made, as Mr. Spencer had said, to last for ages, all that expense and annoyance would be prevented. That was with regard to the first process. Then, with regard to the second, he would remark that the first thing you touched in going into a railway carriage was the door-handle, which was made of brass, and very expensive; but, by M. Dodé's process, it could be made of iron, which was much stronger, and, of course, it would look like silver, and serve equally as well.

Mr. Manning said one ounce of experience was worth a pound of theory. He had been to Paris to see the process carried out, and the stove now exhibited he saw in its original state of cast iron; it was coated by M. Dodé in his presence, and put through the furnace and turned out in the condition in which it now appeared, having been twice in the furnace in the space of 12 minutes. As regards the cost, he was obliged to take the figures given him, but he was told that the difference in cost of platinising and nickelising was £3 4s. He saw there were some flaws in some of the articles, and the reason was explained in this way: that there was a certain amount of damp which had not been removed; all this could be avoided by thoroughly drying the iron in the first instance. There was no polishing whatever, it came out of the furnace exactly as it now appeared.

Mr. Daw remaked that it had been put forward that this process would supersede galvanising, and if the complete process could be done cheaper than galvanising no doubt it would, but he doubted whether the first process only would do so, even if it could be done at one-fourth the cost. If the inventor could give any further information as to the results of the first process on common iron it would be interesting.

Mr. Spon asked if the prices of nickeling, with which the cost of this had been compared, were the prices in London, Paris, or New York; because it was comparatively an expensive process in London and Paris as compared with New York, where there were upwards of 200 nickel-platers, while he did not think there were more than three in London, and certainly not 20 in the kingdom. The stationers' shops were now full of nickel-plated pencil cases, the majority of which were imported from the United States, a great number of them having been sent to New York, nickelled and returned. Consequently the expense must be trifling there, or the price would not pay the expense of carriage to and fro and the high duty. There was no doubt in a year or two nickel-plating would become as cheap in England as in America, and therefore the present prices would not form a basis for calculation.

Mr. Manning said he only took the prices given him, which no doubt were the Paris prices.

Mr. Raper said when he expressed an opinion that this process would not be likely to supersede galvanising, he meant his remark to apply to the common and cheapest kind of galvanising; the ordinary coating of iron with zinc by an acid bath. He thought Mr. Spon was slightly mistaken as to the cost of essential oils, and that there were oils which would answer quite as well as the particular one named. If it would stand the heat, the first process might very well be applied to stoves instead of black lead.

Mr. Spencer wished to make a remark on the theory of adhesion, and the action of the essential oils in this process. These oils consisted almost wholly of hydrocarbons. The doctrine was almost settled amongst chemists that hydrogen was a metal, and there was nothing so well suited for joining metals together as any body in which there was a large proportion of hydrogen. In 1840 he theorised on this principle, and put it into practice in what was called autogenous soldering; by which he brought two pieces of lead together without the intervention of solder, because previously a galvanic action was always set up at the point. He used a blowpipe with pure hydrogen, and fused the two metals together. He then asked himself the question how it was that one thing assisted the plumber's soldering and another did not, and in the "Mechanics' Magazine" for 1840 or 1841, he published a paper showing the different materials and substances which would induce soldering most, and it appeared that they were in the ratio of the hydrogen they contained. With regard to what was called galvanising iron, or covering it with zinc, everyone knew how rotten zinc became by the action of the atmosphere and the sun; it was slightly better than wrought iron, but even for covering buildings it was by no means so perfect as he thought this process would be. It struck him that there was one drawback about this process, namely that, if largely used, it would tend to increase the price of platinum.

Mr. Pearsall asked if there was any possibility that the process which took place in the furnace under the influence of heat would take place gradually by the action of time, if the preparation were applied in places where it would be impossible to heat it afterwards, as for instance in the interstices of wire rope. It was well known that many iron structures were in a dreadfully insecure condition, and it was very common for the police to give notice along the line of a procession that balconies should be avoided. It often happened that though they were constantly painted, the portion of the iron work which was embedded in the wall became quite rotten, and disintegration might also be going on to a great extent under a nicely painted external surface. He had been struck with awe on seeing the shameful state of the wire rope in a bridge over the Thames, where the oxide of iron had exfoliated in lumps like bunches of currants. That bridge had since been painted, and when he last inspected it he found that the paint had been put on over these masses of oxide. In such cases as this the invention now brought forward would be of immense importance, if the preparation were allowed to work its way into the interstices of the cable, and it would then protect the surface of the iron. When one metal was laid upon another there was almost always a galvanic action, so that in the case of a tinned saucepan, or galvanised iron, if the tin or zinc got knocked off, the metal underneath would be destroyed much more quickly than if it had never been protected.

The Chairman asked if any of these stoves had been used, because the point occurred to him that by changes of temperature the enamel might, to some extent, become detached from the iron; on the other hand, it might be so exceedingly thin that it would expand with the iron and not peel off. He always liked to see specimens not quite perfect, which had been somewhere so as to show the defects. Mr. Spencer had referred to the pin holes, and with a magnifying glass he could see them, though they seemed exceedingly small; but he should like to know if any specimens had been tested for any length of time in the atmosphere from the acid fumes. One other question of great importance to him as a chemist was, whether iron vessels could be coated with platinum by this process, so as to take the place of

the very expensive vessels which were so useful in a laboratory.

Mr. Stoffel said they had had a stove in use in Paris all the winter, burning coals or coke 16 or 12 hours a day, and it showed no difference in appearance from the one now exhibited. As the invention was a novelty, they could not give a longer experience. But they now turned out better work than at first, as would be seen by examining some of the small articles now shown. One ornamental casting in the room had been exposed to rain and frost all the winter, and other specimens had been exposed nearly a year, and had not shown any deterioration. The greatest precaution required was to see that the iron was thoroughly dry. The mineral composition, which was the essence of the invention, melted and went into the iron, closing the pores and giving a perfectly secure surface. On this the platinum, or gold, was deposited, and it was in this way that they were able to decorate articles as shown with an infinitesimal quantity of precious metal. It was found that it took about 20 times as much gold to gild a piece of iron in the ordinary manner as it did by this process, and it then only looked gilt, whereas by this method it looked like gold, and would wear 10 times as long. There was not 6d. worth of platinum on the stove. The cost really consisted in the manipulation and furnace operation. It did not matter what oils were used. Those made use of in treating the objects exhibited had cost at Paris 17 francs the kilogramme, or about 6s. 6d. per lb. There was no burnishing required if the second process was adopted. He would point to a panel for a balcony, platinised on both sides, which had not cost 2s. 6d., and would not cost so much in regularly appointed works for the purpose, and this was not much more than it would cost to give it three coats of paint. Platinum could be applied to the surface of bricks or porcelain by this same system, exactly as it was to glass, and it was anticipated that great use would be made of it for this purpose in order to reflect light in the City of London. The cost of this application to the surface of white brick would be, he expected, about a 1d. per foot, and no atmospheric influence could injure it for a considerable period. With regard to vessels for holding acids, he could only answer as yet for small vessels. No acid would attack a coating of platinum, and if three or four coats were applied on well prepared iron, a substantial vessel could be prepared for containing acids, but it would require several coatings, and it must be done with great care. Several very stringent tests of durability were made at Messrs. Johnson and Matthey's laboratory. Pieces of iron brought from the Carron Company were treated on the spot, and were then subjected to the action of hot steam for 48 hours, and never varied. Afterwards, they were subjected to the action of acids and alkalies in a sand bath for 48 hours, and did not vary. Upon that, a very favourable opinion was expressed as to the importance of the invention, and it was stated at the same time that, if they had it in use in the North of England, where alkali and bleaching works destroyed iron roofs to such an extent that they had to be renewed every three years, it would be of immense service. In some respects, cost was a secondary consideration; but they had settled beyond doubt that the cost of the inoxidation process was less than that of galvanising. The high price, and the scarcity of platinum, had been mentioned as drawbacks to its general use; but eminent mineralogists have expressed the opinion that the supply obtainable from Russia alone would be amply sufficient for a far greater demand than that at present existing, and that large unworked deposits of it are to be found in other localities. By M. Dodé's process, crude platinum can be made use of, and the costly operation of refining the ore, and getting rid of its alloys of osmium and palladium, which so greatly enhances the price of the purified metal, is entirely dispensed with. The infinitesimal quantity needed to coat a large surface, must also be taken into consideration. The method of applying platinum to the surface of ceramic substances, mentioned by Professor Spencer, was actually discovered by M. Dodé's grandfather; and after being carried out by him in Germany at least 70 years ago, was subsequently introduced into England, and practised at Tunstall, in the production of what is known as "lustre ware."

The Chairman said it was somewhat remarkable that two processes, which would, no doubt, prove of great importance in the future, each devised for the purpose of making iron a permanent metal, had been developed in that room on successive evenings. He did not wish to express any opinion as to the relative merits of the two, but he believed that each had a great future before it; the appearance of the iron after undergoing the coating was very different, and time and experience would show under what circumstances one process or the other might be used with most advantage. He concluded by moving a vote of thanks to M. Dodé and Mr. Stoffel.

The resolution was carried unanimously, and the meeting adjourned.

MISCELLANEOUS.

"POSTING-PROOFS," A POST-OFFICE REFORM.

By A. Clifford Eskell.

Whilst modifications, alterations, and additions have been made from time to time, and are still going on in almost every branch of postal arrangements, of which it is matter for grave question whether they are profitable or otherwise, strange to say, in one particular direction, and where an immediate profit might be gained, offering advantages to the public not otherwise accessible to them, there has been no attempt at improvement, nor has there been any legislation whatever, not even since the penny postage scheme—the greatest social blessing we enjoy—was promulgated, now nearly forty years ago. The time may therefore be considered ripe, as the Government recently showed some disposition to move in the matter, for the discussion of the necessity of forming a new but voluntary adjunct to the Post-office, for the purpose of perfecting, as it were, and completing Sir Rowland Hill's admirable system, without which, "such is the mood and temper of the age we live in," we could hardly be said to exist.

The scheme, to which I shall presently refer, is not exactly one of dry detail, devoid of general interest, and only intended for the consideration of commercial or business men; it will be found applicable to the requirements of every class of society, and will form an agreeable as well as profitable addition to Post-office administration. From its nature it is unlikely to interfere with or to disturb existing arrangements, and if the views I take of it be correct (of which I hope to convince my readers), it is calculated to lessen some of the errors and unpleasant mistakes which frequently arise to bring the department into disrepute, when it is the public who are generally at fault, though they are powerless to act differently until a remedy be placed in their hands to which they could easily resort.

Such a remedy is to be found in the scheme I am now proposing. At the commencement of the year 1840, when the Penny Postage Scheme was started, the consideration of Government seemed to be, and doubtless continues down to the present day, to deal with the ever-increasing number of letters poured into their offices, and to see that they are accurately delivered.

In this respect no exception can be taken to the general correctness of the *employés* of the Post-office; they are evidently selected with care, belong to a trustworthy and intelligent class of men, and take great interest in their duties; they appear to be well officered, and under strict surveillance; everything, therefore, that it is possible to accomplish to detect neglect or indifference, as well as to ensure prompt and accurate delivery of letters, is done by the administration, and so far it demands our respect, and deserves the highest praise for the undoubted excellence of this part of its arrangements.

It connot be denied, however, that Government is placed at a considerable disadvantage, and is not in a like position to see that letters intended for delivery, and presumptively confined to their care, are placed within the security of their office walls. Too often complaints reach them of alleged missing letters having been safely posted, and of never having been delivered; when inquiries made afterwards prove they never reach the office, and were not even addressed. In this, and many other similar respects, the Government cannot be blamed for a defect hitherto inherent in the nature of postal arrangements not under their control, and not attributable to any other cause. The remedy suggested to overcome this never-ending difficulty is to obtain, when required, by an easy process (which I shall presently explain) a proof that letters were handed in at a post-office, such letters being considered of sufficient importance to require some recognition of having been posted, though not necessarily requiring to be registered. This is, in plain language, the gist of the undertaking; and if I can show how it can be effected with ease to the administration, and inexpensively and pleasurably to the public, I shall consider I have not laboured in vain in calling public attention to it.

Not less than one billion two hundred million of letters, post-cards, newspapers, &c., on an average pass through the Post-office annually—without reference to the number of telegrams sent—but I do not propose to deal for the moment with anything like this number, nor even with a thousandth part, and it would answer for the purpose of illustration not to consider a ten-thousandth part; but this by the way. If these letters, say, at the rate of one important letter to every five thousand unimportant letters, could be proved to have been correctly addressed, stamped, and placed in the hands of the Post-office authorities—and it is a mere speck in the numbers posted—it would, irrespective of the advantages to the public (to be considered hereafter), help to lessen the troubles and inquiries made at the missing-letter department, and, if the calculation I have made be correct, it would yield an income of not less than £200,000 a year.

To effect this important improvement without imposing on the officials heavier duties than they can readily perform, is a task not to be lightly disregarded if the project is to receive encouragement; and at the same time to make the addition a profitable adjunct to the Post-office worthy of its deepest consideration, becomes a necessity; for, without pretending to be too intimately acquainted with the working of the machinery behind the scenes, it may be doubted whether registered letters, at 2d. each, pay sufficiently well to produce a profit; whether Post-office orders from 2d. to 1s. each do not entail a loss, or whether even the 1s. telegram is lucrative (if the interest upon capital expended be added to current expenses). It may be answered, however, that we (the public) have nothing whatever to do with what pays or does not pay at the Post-office. It does not concern us individually; and, as it is an institution specially designed for our use and convenience, the Government is not to be supposed to look too narrowly into the question of profits. This may sound very well in theory, and is, no doubt, an easy way of solving an insurmountable difficulty, looking at it from a philanthropic point of view; but still, the Government, like traders, ought to see that its expenditure, if possible, does not exceed its receipts, and that it pays its way if it can; otherwise, the greater the business the greater the labour and anxieties, and the greater the losses. Whether we should stand quietly by and be indifferent as to results, one way or other, it is not my province to inquire, nor is it my intention to discuss; but, if I cannot show any probability of profit arising from the introduction of the scheme I am advocating, it would simply lead to its rejection, and even my readers may be disinclined to look favourably on the project.

In my first applications to the Government in 1865, I suggested that booked letter receipts, in the form of convenient slips of paper (a printed arrangement showing where to put a name and address on), should be sold at all the offices, ready stamped by Government, at a farthing each, and if any of the public wanted proof of their letters having been received for dispatch and delivery, they had only to fill in previously on the slips of paper the names and addresses corresponding to the names and addresses on the letters, when, if the clerk behind the counter found they corresponded, he would officially impress with a date stamp the slips of paper, handing them back to the messenger, and would himself take care that the letters (of which the receipts or proofs purported to be copies) did not leave his hands, but were put into the proper receptacle for usual collection and despatch.

It should be borne in mind, in shadowing forth an outline of the scheme which will be more fully detailed hereafter, that it is not to be considered in any other light than as a voluntary adjunct to the Post-office, for the purpose of enabling the public to prove, at a very small cost, that the more important of their unregistered letters, when required, were handed in at a post-office. It is not intended to apply to the mass of letters, nor to general correspondence. And I would ask, who is there among us who has not, on some occasion or other, some letter or letters of a character more important than ordinarily occurs, which need not be registered, but still of which some tangible evidence of having been sent to post would be appreciated? It is with these very letters I wish to deal, and to include, in their same category, irrespective of telegrams, the number of letters which are never thought of as worth the expense of registration, or with which registration is avoided from motives of economy or something worse.

It might be imagined by unreflecting persons, that registration of letters would be interfered with, and that the returns in that department would be seriously affected; but such could not possibly be the case, for registration being imperative and compulsory where coin, valuables, and jewellery are concerned, there could be no evasion; and where a signature is required from recipients of letters or documents of value, it could not be obtained without the aid of registration. As the system would not interfere with, so on the other hand it could not supplant, registration, with which it is in no way identified; as where registration is required and absolute this system would not be touched, and where this system applies, registration would not be resorted to.

If the public preferred the system I am now treating of, and chose to abandon registration as far they could, it is not unreasonable to suppose the Government would be great gainers, as for every letter registered twenty would be proofed—in other words, twenty posting-proofs at a farthing each would be used to show they were duly posted, and the labour would be less onerous and troublesome to the Government. And as the Post-office is constituted for the convenience and benefit of the public, as already remarked, it could make little difference to the administration which branch of the Post-office was specially favoured.

The advantages of registration to the public are undoubted, and the price is not excessive, considering the trouble, care, and expense the department is put to to ensure safety and faithful service, and it is surprising it

is not more resorted to, and shows either the weakness (or wickedness, I was going to say) or poverty of the people, when 90 per cent. of the letters which ought to be registered are sent to post as ordinary letters. The returns from this department are wonderfully meagre (only £72,000 per annum from all the offices in the United Kingdom).

I do not know whether I am right, but I am open to correction, in stating that since the reduction of registration from 4d. to 2d., the amount has fallen short of previous returns! If this be so, it is a proof that registration is only resorted to where it is unavoidable, or where some important object has to be gained. The previous charge of four-pence was not too much to demand under these circumstances, and for the extra care, expense, and labour entailed on the Post-office; and it is questionable whether the fourpenny rate acted more restrictively then than the reduced price of twopence does now; at any rate, the same objectionable influences prevail, and considerably more than double the number of letters must be registered at the present time to place the profit and loss of this department on the same footing as it held prior to the change mentioned in the last annual report of the Postmaster-General.

Contrast the returns of the registered letter department for the moment with the expectation formed of the anticipated revenue from the introduction of posting-proofs; and in endeavouring to arrive at an estimate of the probable amount, I am actuated by a desire to keep within the bounds of probability; and I think, on reference to the figures, I have not exceeded it.

It may be summed up in a few words—that if 2,000 offices stamped 300 posting-proofs each per diem, the annual income would not be far short of £200,000, and 12,000 offices have been shut out of all calculation! Or take 10,000 offices, and apportion a ridiculous minimum to each of only thirty posting-proofs per day, and the result will be the same. It should be understood that there are 14,000 offices in Great Britain, irrespective of pillar-boxes, and the revenue derived in this way would be more profitable than that which could be obtained from any other department of the Post-office. There would be no expense for materials, and the labour for the amount named would be reduced to the most trifling character. But if it only brought in £10,000 a year income, with advantages to the public, it ought not to be withheld from them.

Ninety per cent. of letters which ought to be registered are not the only letters which would be embraced by this system. There are numbers of letters that are not truly not worth the expense of registration, and still of which an acknowledgment of their reception at a post-office would be valued; such, for instance, as those, amongst others, of important orders or countermands, or those which contain post-office orders, cheques, or again, manuscripts and documents of more than ordinary interest, not sufficiently valuable to warrant registration; and even telegrams, for which receipts are never obtained, would be treated to a posting-proof, alike inexpensive and satisfactory to the sender, and sufficiently remunerative to the Government for the trouble of comparing two superscriptions and stamping a piece of paper with an official date, which indicates at the same time the office where the letter or telegram was received; the work on the part of the post-office commencing and ending in two or three seconds' time. The public will cheerfully pay one farthing each (there being no smaller coin current), and will take all the trouble and labour for the satisfaction of knowing and being able to prove their letters were safely placed in a post-office for despatch and delivery.

The system, as it became better known and understood, might ultimately be found so advantageous that it would not be surprising to find the Government reducing the cost to the public and furnishing posting-proofs, in numbers, at the rate of six or eight for a 1d.

To sell this grand secret or knowledge thus solicited from the Government for more than one farthing per letter, especially at the outset, is not only exorbitant and detrimental to the extension of the scheme, but is more than, in my humble opinion, the public will feel inclined or ought to pay, and I have persistently urged, as a first condition of success, that the farthing stamp would make the adoption of the system more general as well as sufficiently remunerative to the Post-office.

Deviating from this important particular, it is deeply to be regretted that Government, in a partial and limited trial which was made at Liverpool, Birmingham, and Bath, did not keep to the price of one farthing for each posting-proof instead of one halfpenny, although the price, of itself, was not the only drawback to mar the success of the scheme at the places mentioned.

For one halfpenny the Government will take your open-ended letter or your post-card; or will take 2 ounces of manuscript, or a newspaper, convey it 800 miles, and deliver it at its destination, the trouble, care, expense, and labour involved in these duties being covered by the charge of one halfpenny; but it surely cannot, by way of comparison, be worth more than one farthing to take in a letter across a counter and stamp a piece of paper, after verifying two addresses to see they were alike, the labour and expense commencing and ending in the same two or three seconds of time. To charge one halfpenny for this modicum of service is tantamount to prohibiting the use of the scheme altogether, as it cannot be denied that the general public study economy, especially in business details, and would object to pay more for a thing than it was really worth. Few people would be induced unnecessarily to add 50 per cent. to the postage of their letters, and 100 per cent. to the postage of post-cards, although they might not object to as small an extra fee as possible, for the trifling assurance they require.

The conveyance and delivery of the letter or post-card being already covered and paid for by the penny or halfpenny stamp affixed to the letter prior to posting it, the new adjunct can make little difference to the duties of the Post-office, as, by an arrangement with each office, according to the demands made upon its time, posting-proofs could be stamped before or between certain hours (the busier the office the earlier the hour), after which posting-proofs would not be compared. Thus, in some offices the hour might be as late as eight o'clock, at others five o'clock, at others four o'clock—in this way the pressure which sometimes takes place at large offices would be relieved if a number of the letters found their way into the box an hour or two before the busiest time arrived.

Presuming, however, that the plan of obtaining posting-proofs were taken up with avidity by the public, the Post-office could organise a better system generally, tending to spread the work of the offices more uniformly over the day, and to greater accuracy and correctness in the posting of important letters which would permeate through, or re-act on, the various succeeding departments, ultimately ending in their proper delivery, and often absolving the Government from the usual blame which is unhesitatingly applied to them under almost every circumstance of loss or delay.

Important or unimportant letters go astray, whether posting-proofs be taken for them or not; but if the public, for their own convenience, are willing to take the trouble to be more precise with some letters of which they desire to retain a record on their own account, and to pay a small rate for that privilege, the Government have hardly a show of reason to refuse them; for the arrangement required to carry out this plan is of such a simple nature that it only requires to say the word and the system could be commenced and carried into effect without delay. Whether it would be so quickly comprehended on a short notice as if a month's prior publicity were given to it beforehand, is not so obvious;

however, there need be no dislocation of departments nor machinery; all that is necessary to be done is to have posting-proofs on sale at the various offices, and to instruct the *employés* to stamp them, after comparing names and addresses, when brought to the office for that purpose. An explanatory notice at the offices, and a circular, pointing out the uses and advantages of the system, given to the first purchasers of the posting-proofs, and its utility would spread almost like wild-fire from person to person, and in a short time the only wonder and regret might be that the plan was not adopted at a much earlier date.

And here it may not be out of place to remark on the difficulty experienced of introducing any novel undertaking, however meritorious, or of getting it officially recognised and carried properly into public favour, against the discouraging influences of prejudice, and the dislike of innovation.

It is to be expected, and is not surprising, in the face of schemes involving great radical changes, and a total deviation from all preconceived ideas and routine. Notably, in the instance of the penny postage scheme, when the opposition to it was so great that it was denounced by the authorities as ruinous, and ridiculed by them as visionary, Lord Lichfield, then Post-master-General (1837), said of it, in the House of Lords, ' Of all the wild and visionary schemes which I have ever heard of, it is the most extravagant." And, in 1839, Col. Maberly made observations of an analogous nature, when he said: "My constant language to the heads of the departments was this, 'this plan, we know, will fail; it is your duty to take care no obstruction is placed in the way,' &c."

Observations of a similar character might apply to the present scheme, were it not that, instead of disturbing and upsetting existing arrangements, it might rather be looked upon as a valuable adjunct to the other departments, helping in a great measure to correct errors, and remove complaints which cannot otherwise be reached by any other known auxiliary of the Post-office, and that this view of the case must have some show of reason to support it, is borne out by the fact that it was decided to give the scheme the trial I have alluded to, however ineffective and indifferently it was carried out.

It is a difficult thing to ascertain whether the public would resort to any scheme which has never been tried before, and of which there is but scant knowledge afforded to them; but, upon the principle of creating the supply, and demand will follow (reversing the old principles of political economy), and disseminating the knowledge properly among the people that a supply was available, the result would, I have little hesitation in saying, be most gratifying. Railways were created on this principle, and where one person travelled in years gone by a thousand stayed at home; but now it requires no sage to assert that the reverse obtains, possibly, in a much greater degree. In like manner, if facilities were first afforded, no matter in what branch of trade or science, and they became known, and were found to be useful, the public resorted to them without hesitation. Acting upon that principle, if posting-proofs are placed within reach of public comprehension, they will become so much a matter of necessity as to be indispensable.

On February 19th, 1877, I had an interview with Lord John Manners, and personally propounded the the nature of the scheme I was desirous of seeing added as a permanent but voluntary adjunct to the Post-office, and, after some lengthy correspondence, my object was so far attained that, on the 9th of November, in the same year, the following paragraph appeared in the *Times*:—

"Certificates for Unregistered Letters.—Representations having been made to the Postmaster-General that it would be very desirable in many cases to have a certificate showing that a letter, newspaper, or book-packet had been posted, without registering it or obtaining for it any special security, it has been decided by the Post-office authorities to try the experiment of issuing certificates of this description at Liverpool, Manchester, Birmingham, Bath, and some of the principal offices subordinate to those places. Forms of certificate, with an embossed halfpenny stamp, will be sold to the public, on which the sender of a letter, &c., must write the address, and present it with the letter to the clerk at the counter. After examining the address, the Clerk will retain the letter, newspaper, or book-packet, and return the certificate to the sender, impressed with the dated stamp of the office as evidence of posting. The subsequent treatment of the letter will be precisely the same as if posted in a letter-box. No certificate will be given for letters containing gold or jewellery."

No further allusion was made to the system at any subsequent time. On the 12th November, three days afterwards, a small similar announcement appeared in the Liverpool papers, and presumably in the Birmingham and Bath papers, as they were also mentioned in the above paragraph, and on the 14th inst., two days after these announcements, the system was understood to be in full working order. There were small placards, intimating that "certificates of posting of unregistered letters" could be obtained, put up at the various offices. The Post-office Guide, under a similar heading, conveyed the same information. Nothing else had been inserted in the newspapers; no explanation of the system, nor of the advantages sought to be obtained by its introduction, had been accorded; and it is no matter of surprise that the general public, ignorant of its existence, and naturally unaware of the facilities or advantages offered, should have been unable to resort to it. If noticed at all by any of the community, it has been under the supposition that it was some form of registration not coming exactly within their own requirements. The foregoing remarks are based upon ascertained facts, which may explain some, though not all, of the reasons why the scheme has not been sufficiently recognised at Liverpool, Birmingham, and Bath.

I have objected, from the very first announcement of the intention of Government to try the scheme at the places mentioned, to the title of "Certificate of Posting of Unregistered Letters." It is misleading, and has a wider significance than is implied by the mere act of stamping a form already purchased and filled in by the purchaser with all the writing required.

I have also considered, since the preliminary trial referred to, that it is possible an objection may have been taken to the word "receipt," as implying a degree of responsibility which, the legal advisers of the Post-office intimate, should not be admitted in a transaction of which no note is taken and no record preserved; but in seeking to avoid the semblance of responsibility they have, unfortunately, gone over too much to the other side of safety, and stumbled on a term which conveys no impression of the object sought to be attained; hence, amongst the causes of failure at the trial at Liverpool, Birmingham, and Bath, the selection of a phrase possessing no special feature to attract the attention required, has allowed the scheme to be perfectly unrecognised; and if closer attention had been called, the title itself might be easily construed to mean, that all letters not registered were to be considered as embraced by this system, which is far from being the case.

Desirous, however, of removing any obstacle which might arise to the due trial and working of the plan, I have since suggested and adopted a more unobjectionable phrase than postal or booked letter receipts, and that is "Posting-proof," or "Proof of posting," which conveys the idea to the public mind that they can satisfy themselves, without troubling Government in any way, that certain letters were undoubtedly posted; and this ends the matter. Hence all difficulty is removed on the

score of designation and responsibility. But if we reconsider the singularly inappropriate title, the charge of one halfpenny instead of one farthing, and add to these the absence of all due publicity, in the shape of repeated announcements in the public newspapers, and circulars sent round to the householders explaining the system one or two months beforehand, it can easily be understood that there was no chance of the plan succeeding at Liverpool, Birmingham, or Bath, after being virtually sprung upon the people without warning or comprehension.

My contention is, that it only requires full publicity to obtain for it the attention it deserves. It will then be for the public to use it or leave it alone, exactly as they do now with registering their letters, using post-cards, &c. They should be encouraged to try the scheme, but there is no compulsion; if they (the public) are satisfied with its merits and advantage, it will soon grow into favour, and they will use it without hesitation, and the more they approve of it the more it will be in request and reckoned as part of the institution, and the greater the benefit that will be experienced on all sides.

It is upon these grounds I have been induced to commit to paper the course pursued by the Government, which is hardly worthy of defence and cannot be denied, to induce the general public to take up the matter with sufficient interest to urge upon the administration the reasonableness of giving the system a fair trial, when, if it failed, no reproach could be uttered against them. There is nothing in this straightforward plan which would tell the Government they are in any way compromised, and they could abandon the system without loss or disturbance.

As for the counter-space being required, to which the Postmaster-General referred in one of his letters, I cannot see that it would be any more objectionable for this scheme than for the taking in of registered letters; and that the post-offices are closed at Liverpool from Saturday evening to Monday morning, no more applies to this system than it does to any other department of the Post-office. I might infer, from the preceding remark, that it was contemplated at head-quarters there would be a possibility of increase of business, but it would be a profitable accession, for the transaction of which Government should be as willing to provide as traders would be under similar circumstances; how advantageously female labour might be utilised for such work as this scheme involves need only be mentioned.

The usefulness of this scheme is not militated against by the establishment of pillar-boxes, any more than they interfere with the system of letter registration, Post-office orders, the sale of stamps, &c.

These remarks of the Postmaster-General cannot surely weigh with the public as against the broad fact that the scheme is entirely unknown, and has, so far, not had the slightest chance of being resorted to nor of being approved of. Besides the want of due publicity complained of, its title and price were equally at fault to attract attention; and for the benefit of my readers I will describe some of the advantages, which possibly may show wherein the scheme would be useful to them individually, premising *à priori* that posting-proofs are small slips of paper ready stamped by Government, stitched together like bankers' cheque books, which they resemble, only being much smaller, from which they are detached in a similar manner, one being handed in at a post-office for marking with each letter, the address of which it is presumed to be a copy, and they are to be used as occasion requires, or as may be desired, for letters containing post-office orders, cheques, important orders or countermands, or for the acknowledgment of telegrams, the returning of manuscripts and other documents, as well as for letters of more than ordinary interest from all classes of the community.

The advantages are these:—

1. Undoubted evidence of the reception of a letter, telegram, parcel, &c., at a post-office at the cost of one farthing (the smallest coin of the realm).

2. Affording a complete check upon the honesty and punctuality of messengers.

3. Delay of letters, whether in posting or delivery, would be easily detected, and the blame traced to the proper quarter.

4. In courts of justice, and for any legal proof, the production of a proof of posting would dispense with the evidence of witnesses, clerks, books, &c.

5. Correspondents could always have the fact substantiated.

6. Posting-proofs (addressed to themselves) could be inclosed to correspondents by parties who wished to have certain knowledge that letters were posted back to them as requested.

7. It would prove the posting of a letter without the receiver being made aware of it, or calling upon him to acknowledge it, as he would have to do if registration were resorted to; letters however, containing coin or jewellery must be registered in accordance with the regulations of the Post-office.

8. Letters not addressed at all, or insufficiently stamped, could not by this system be received at the Post-office, thus offering an immediate check upon oversight or error; and it would often be found by the parties themselves that letters were wrongly addressed, without troubling the Post-office with an unneccessary complaint.

9. The business community would have no more trouble than they have at present, as names and addresses for reference or record would only have to be copied on to posting-proofs, instead of into the ordinary letter-book.

10. Invalids, elderly persons, or those who make it a practice to post their own letters (despite even the conditions of weather) could always send them, being able to obtain convincing proof that they reached the office in safety, from the officially stamped posting-proofs returned to them by the messenger.

11. Editors and authors generally, who make it a rule to return manuscripts, would invariably use posting-proofs as due to their correspondents, without troubling them to sign acknowledgments, as with registration and post-office orders.

12. Names and addresses on letters, as they must be plainly and legibly written, would be easier deciphered by the postman who delivers them, and there would be less chance of their going astray or being left at a wrong address.

13. Inquiries after lost or delayed letters would be much facilitated by the production of an officially stamped proof of posting, investigation not going further back than at the office where, by this system, the letter was proved to have been posted.

Some examples of usefulness may be indicated by the following observations:—

As a rule, the Post-office performs its functions in an admirable manner, but it is often troubled to inquire after letters which, probably, have never been posted; even friends carry letters about with them for days, and do not (such is the perversity of human nature) like afterwards to give evidence of their neglect. And messengers sometimes lose them from carelessness, or are intentionally dishonest. There can, therefore, be no better nor safer check than to obtain stamped posting-proofs for letters of more than ordinary importance, which, for the sake of one farthing each, places the posting beyond a doubt.

It frequently happens that an important order, or an important countermand, is sent by post in the ordinary way, and a doubt crosses the mind of the sender whether advantage will not be taken of it to say the letter was not received, or did not arrive in time to be acted upon. To register it would be to give offence, and might lead to unpleasantness; but a posting-proof would show the date the letter was sent to post, and the probabilities are it was delivered in due course afterwards.

The Postmaster-General's Report for the year says that 25,000 letters were posted without any address; with a posting-proof an unaddressed letter is impossible.

In the case of a lost letter, the present system is to write to the Post-office, complaining of the non-delivery of the letter at its destination. An official note is returned, enclosing a form to be filled up with full particulars, which, as soon as complete, is forwarded to the Post-office. This takes time, but that is not all, the name and address written on the form may not be an exact counterpart of what appeared on the letter; there may be a difference in the name of a street, or in the number of the street, or it may have been addressed to a wrong town, all essential elements in helping to trace a missing letter; filling up a form in this manner, from memory, cannot therefore be of much assistance, whereas if a posting-proof had been resorted to, there would have been a quick search, and more chance of success.

To the illegibility and the errors of addressing may be traced the loss of more letters than from any inherent defects or irregularities of the Post-office. Where letters are delivered wrongly (and they are not opened by persons for whom they are not intended), they are allowed to lie about for a long time, and find their way ultimately into the waste paper basket or the fire, instead of being given back to the postman.

Directions for Use.

The name and address on the letter, for which an official acknowledgment is requested from the office where it is posted, must be exactly copied on to the proof of posting; it must be clearly and legibly written in ink before being brought to the clerk at the counter, who will take the letter and compare it with the proof, when, if he is satisfied that the superscriptions are alike, and the requirements of postage have been fulfilled, he will stamp it with the date of reception and name of office, handing it back to the messenger, and placing the letter in the usual receptacle for collection, the messenger who brought it not having anything more to do with the letter after once the proof of posting has been stamped for it.

On attaching the proofs to the face of each letter (when numerous) by a corner of the gummed part they can be conveniently carried to the office, and the clerk on duty can compare superscriptions more readily, tearing each proof from its slight adhesion, applying a perforating stamp to several together when it would take up too much time to do each singly.

The posting-proofs can afterwards be replaced into the books, or they may be gummed to any document, as may be required for convenience or future reference.

The posting-proofs are stitched into coloured wrappers in numbers of 24, 72, 144, and so on—perforated like bankers' cheque-books, for easy detachment, and gummed a little way down the back of each, for the purpose of replacement, when officially acknowledged, into the books they are torn from, for record and reference, or of gumming them to any document, as may be desired. A proportionate charge of one halfpenny per dozen is added to cover the expense of paper, printing, perforating, gumming, stitching, &c.

The scale of charges is as follows:—

1d. for three.	
3½d. per packet of one dozen.	
7d. per book of 2 dozen	(grey wrapper.)
1s. 9d. per book of 6 dozen	(yellow wrapper.)
3s. 6d. per book of 12 dozen	(blue wrapper.)

Books to contain greater numbers can be obtained if desired.

In this plain and unvarnished manner I have attempted to give an outline of the system which, as a voluntary adjunct to the Post-office, might do much good service to the public and to the State, and it rests with the people themselves to say whether I have exaggerated the benefits and the revenue likely to be derived from its introduction, or whether I have not underrated its importance, as, when once it is established, numerous directions of usefulness will be discovered, hardly to be thought of at this early stage, while the subject is yet in abeyance, and before actual demonstration of its principles has been allowed to develop its powers. Thus, this very system which is so earnestly pressed upon the notice of the world crops up now, and is simply built upon the out-come of the working of the penny postage scheme, with all its ramifications of registered letters, halfpenny post-cards, and post-office orders, &c. It was 25 years in operation before the applicability of this new adjunct could be discovered and arranged, and it has taken 15 years' incessant application since then to different Governments before it was allowed to engage the attention of any administration; with what success it has been attended up to this present date I will leave my readers to judge.

Suffice it to say, as a voluntary adjunct to the Post-office, if made use of only to the moderate extent anticipated—and there is no reason why it should not be in as much demand as any other department of the Post-office—it will help to make the penny postage scheme approach as nearly to perfection as anything that is designed by human brains and hands can do; and it is to be hoped the Government will not be insensible to the solicitations of the public, but will take the initiative without further appeal, and open up a new and profitable undertaking, giving them a fair opportunity of testing the scheme, on the broad principles I have endeavoured to make clear to ordinary comprehension.

It will, otherwise, be at variance with public polity to withold much longer a boon possessing, on the face of it, the elements of utility to the world, and increased revenue for the use of all Governments adopting it.

NATIONAL WATER SUPPLY.

The *Times* of Saturday last had the following leading article in reference to the Society's action on the question of national water supply:—

"We published yesterday a letter addressed by the Prince of Wales to the Premier on the subject of the improvement of the national water supply, and it may fairly be assumed that the answer, in which Lord Beaconsfield states that he has referred the matter to the Board of Treasury for the careful consideration of their Lordships, implies his own recognition of the importance and the urgency of the case. The subject is one in which the Prince of Wales has long been known to take interest, and it was in consequence of the action of his Royal Highness, as President of the Society of Arts, that a Conference on water supply was held in the rooms of the Society in May, 1878. The Prince now supports the chief resolution of that Conference, which was to the effect that a small permanent scientific Commission should be appointed, to investigate and collect the facts connected with water supply in the various districts throughout the United Kingdom, in order to facilitate the development and use of all the sources of this supply for the benefit of the country as a whole. The labours of such a Commission would not be limited to the questions involved in the supply of towns and other large centres of population, but would embrace also the condition of villages and scattered groups of houses, in which, there is too much reason to believe, the use of unwholesome water is a frequent source of disease, even to an extent which, in the aggregate, seriously affects the mortality of the kingdom, and the health and strength of the surviving

population. The Commission would further take cognisance, of course, of the various pollutions of water by manufactures and sewage, and would consider how far these pollutions might be prevented without undue interference with industry. There is little doubt, among any who have made themselves acquainted with the subject, that the Act recently passed to restrain the pollution of rivers can only be regarded as a first step in a direction in which further progress is imperatively necessary; and the appointment of the proposed Commission would obviously tend to clear up many questions which are still to some extent involved in uncertainty, and upon the right solution of which the efficiency of any future legislation must greatly depend.

"When it is considered that water constitutes nearly three-fourths of the entire weight of the animal body, that it is the basis of all beverages, and the solvent by means of which all food is assimilated and all secretion is performed, the importance of obtaining it in a state of purity would seem to require no further demonstration. Unfortunately, however, although the facts have for a long time been universally admitted, the practical conclusions to which they would lead have comparatively seldom been acted upon. Not only do we obtain the greater part of our supply of water from that which has already washed the earth, but we have permitted water flowing in its natural channels to be everywhere utilised as a carrier of the worse descriptions of filth. The increase of population tends constantly to render the earth more dirty, and its washings consequently more repulsive and injurious, and tends in the same way to increase the amount of filth which the natural channels are called upon to convey from the vicinity of human dwellings to the sea. Arrangements which were once excusable, and perhaps not necessarily injurious, have been suffered to continue in circumstances of a wholly different character from those in which they originated; and the Legislature has been slow to perceive the necessity of keeping pace, in its provisions for water supply, with the changing conditions under which human life is carried on, with the rapid growth of population, and with the constantly increasing complications of industrial processes. In rural districts, there has been no kind of supervision of the wells attached to houses or cottages; and, in many instances, the inhabitants of large villages are compelled to take from streams which are nothing more than open sewers. In cities privileges have been granted to water companies without any due care that these privileges should carry with them corresponding obligations; and the resulting monopolies are little less oppressive than some of those which excited popular discontent in the days of the Tudors. It would be scarcely credible, were it not a matter of familiar knowledge, that while many provincial towns have a continuous service, the inhabitants of London are still dependent upon cisterns, in which, except when there is an unusual amount of care on the part of the inmates, filth of every description accumulates; while the pipes themselves, periodically empty, are ready to receive sewer gas at regularly recurring intervals, and thus to become formidable sources of contamination. In the lofty houses which are parcelled out among many occupants of humble station, there is often no cistern at all, and mothers of families have to descend at stated times from the upper stories to the standpipe in the street or court, in order to take back again the small amount of water they can carry, in such unsuitable vessels as they can command. In the face of such difficulties, water cannot be obtained in sufficient quantities for washing, while that which is left in an open pitcher in the common living room soon becomes unfit to drink, and, by its repulsive character, is often one of the most potent of the indirect causes of intemperance. Nothing is more extraordinary than the way in which the various societies for the promotion of temperance, or of total abstinence, have neglected the improvement of the national water supply—a reform which would seem to be an essential preliminary to any prospect of general success in their well-meant endeavours. Whether in town or country, as long as water is difficult of access, repulsive to the senses, often unwholesome, and occasionally deadly, it is terribly weighted in its competition with alcoholic drinks. Even the aërated waters of commerce, in which so many people hope to find safe table beverages, cannot be regarded as beyond suspicion until something is known of the sources from whence the water, which is their main constituent, is derived.

"The Conference held under the auspices of the Society of Arts, besides calling general attention to the questions at issue, and passing the resolution which the Prince of Wales has communicated to Lord Beaconsfield, has further done good service by causing the preparation of a little volume, to which we refer in another column, and which contains notes of all previous inquiries in the same direction, together with minutes of evidence upon some of the most important points. The book has been compiled for the Society of Arts by Mr. Mitchell, who within very moderate compass, has brought together the titles of all former official publications about water, with such notes of their contents as will enable any one commencing the study of the question to go at once to trustworthy authority upon almost every part of it; and he has extracted just so much of the reports as to give an outline of the kind of testimony which is available upon different matters—*e.g.*, of that upon which water has been charged with being the channel of diffusion of various forms of epidemic sickness, chiefly cholera and typhoid fever. On this head his excerpts might, perhaps, have been brought down with advantage to a somewhat later date, since they do not include an account of the investigation into the causes of the epidemic of typhoid in the district of Marylebone, which was ultimately traced to the contamination of milk by typhoid-poisoned water. A publication of this kind cannot fail to be serviceable, because the facts with which it deals are published chiefly in Blue-books, and, even when they do not entirely escape notice, they are apt to be soon forgotten. A good illustration of this is furnished by a quotation from the evidence of Soyer, the once famous *chef de cuisine*, who related to the General Board of Health, in 1849, the result of his experiments with different varieties of water in cooking and in tea-making; and we may mention here that later experiments in the use of Thames water for tea-making, as compared with water of less hardness derived from an artesian well, showed that, with the former, it was necessary to use nearly one-third more tea than with the latter, in order to obtain an infusion of the same quality. This one-third, when multiplied by the consumption of the entire metropolis, is not a trifling consideration, and renders it manifest that the proposed Commission, if appointed, will have to deal, not only with questions of health, of cleanliness, and of comfort, but also questions of economy. The Chancellor of the Exchequer is perhaps more deeply interested in water supply than he might at first sight be prepared to admit; but it is certain that, if he should lose by the diminished consumption of duty-paying articles, he will be at least a corresponding gainer by the increased power of healthier and more temperate population to bear imposts of some different kind."

In the *Times* of Monday, a letter, from "The Compiler of the Notes," appeared, in which attention was drawn to the fact that the Marylebone outbreak of typhoid, referred to in the leader above quoted, was really mentioned on p. iv. of the Addenda, and also stating that, though a request for corrections and additional information appeared in the "Notes," no further information and no corrections had been sent.

CORRESPONDENCE.

THE CULTIVATION AND CROPPING OF BAMBOO.

My attention has been drawn to a letter in your *Journal* for 3rd January, from Mr. Thomas Routledge, in which, commenting on the results of my experiments in cropping bamboo for paper fibre, he remarks that "the system adopted of cutting down all growth pertinaceously every successive season could hardly fail to impede if not destroy the ordinary vegetative functions of the plant." I entirely agree with Mr. Routledge in this opinion, and my only reason for troubling you with the present letter is to point out that this system, which Mr. Routledge now agrees with me in thinking faulty, was suggested, not by me, but by Mr. Routledge himself. In a pamphlet on "Bamboo Considered as a Paper-making Material," which Mr. Routledge published in 1875, he gave at some length his views on the treatment of the succulent young shoots of bamboo as a paper fibre, and also suggested a plan for cultivating bamboo for the production of these.

With regard to the value of such shoots as a raw material for the paper maker I have nothing to say. The possibility of cultivating this raw material profitably near any place in India where a paper-stock mill could be advantageously erected is, however, a matter which I have examined with some care, and as to the feasibility of which I have a decidedly unfavourable opinion.

In the pamphlet already referred to, Mr. Routledge describes his proposed mode of cultivation in the following words:—

"The stems of the 'bamboo,' cut young, as I propose to use them, contain from 60 to 75 per cent. of moisture; it will be obvious, therefore, that to ensure a regular and continuous supply under economical conditions, to a central factory for the manufacture of paper-stock, plantations would have to be formed contiguous thereto, as practised with 'sugar-cane,' or in a similar manner to osier beds in England.

* * * *

"With plantations of 'sugarcane,' to which plant the 'bamboo' somewhat assimilates in character and growth, it is necessary, in order to ripen the canes and develop saccharine, to allow free ventilation to the growing plant, and thus the ground is not fully occupied. This would not be the case with 'bamboo,' which should be planted and grown closely together to favour the stems shooting upwards, as practised with 'hemp' and 'flax,' where fine staple of fibre is desired.

"By following such a system, the stools or roots once eastablished, a systematical and regular cropping, or cutting, would ensue, the stems being all cut down simultaneously, by sections or beds, in regular succession, numerous croppings annually would thus be obtained, and when necessary fresh beds would be formed, the older growth being available for fuel for the manufactory.

"The sugar-cane from the time of planting to cutting takes from nine to twelve months to grow and mature; but even thus grown, the produce of canes (ready dressed for the mill) generally ranges from 30 to 35 tons to the acre; it sometimes exceeds 40 tons; allowing several crops or cuttings annually for the 'bamboo,' it may fairly be assumed that at least this latter quantity would be obtained per acre.

"Allowing 208 feet square to represent one acre, divided into twelve beds, each 96 by 26 feet, with twelve paths 96 feet by 8 feet 9 inches wide, and one intersecting road 208 by 16 feet wide, leaves a space for planting equal to 2,496 feet, or 29,952 feet in the twelve beds; allowing the stems to be 2 feet apart, and say only 12 feet high, we have 7,488 stems, which at 12 lbs. each equals 40 tons per acre."

It appears to me impossible to understand anything from this extract but that Mr. Routledge intended that all the young shoots in each clump should be cut, for in his estimate of the annual out-turn of an acre he includes the entire weight of every stem grown on it.

My own opinion of Mr. Routledge's proposed plan has always been, and still is, that it is founded on a total misunderstanding of the mode of growth of the bamboo. But as the advisability of forming plantations on this plan had, as I understood, been pressed upon the Government of India, I felt bound to put it to a practical test on a small scale in this garden. I did so, following Mr. Routledge's instructions minutely, and the results (which were very unfavourable) were recorded in the annual reports of this garden for the years 1875-76, 1876-77, and 1877-78. I am somewhat surprised to find that Mr. Routledge should write as if the system which I followed was one of my own suggestion. It is not my system, but Mr. Routledge's. Nobody can possibly have a poorer opinion of it than I have always had, and in this poor opinion Mr. Routledge is now, apparently, inclined to agree.

George King.

Royal Botanic Garden, Calcutta, 17th March, 1879.

NOTICES.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

April 23.—"English Fresh-water Fisheries." By J. Willis-Bund, Esq., Chairman of the Severn Fishery Board. Francis T. Buckland, Esq., M.A., H.M. Inspector of Salmon Fisheries, will preside.

April 30.—Renewed Discussion on Mr. John Hollway's paper (read February 12) on "A New Process in Metallurgy." Prof. H. E. Roscoe, F.R.S., will preside.

May 7.—"The Government Patent Bill." By W. Lloyd Wise, Esq., Assoc. Inst. C.E. F. J. Bramwell, Esq., F.R.S., will preside.

African Section.

Tuesday Evenings, at Eight o'clock.

April 29.—1. "Light Railways for Opening-up a Trade with Central Africa," by John B. Fell, Esq.; and, 2. "The Advantage of Railway Communication in Africa, as compared with any other Mode of Transport," by J. Conyers Morrell, Esq. Captain Sir Henry Tyler will preside.

May 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

Chemical Section.

Thursday Evenings, at Eight o'clock.

May 8.—"The History of Alizarine and Allied Colouring Matters, and their production from Coal Tar." By W. H. Perkin, Esq., F.R.S.

May 15.—Continuation of Mr. Perkin's paper.

Indian Section.

Friday Evenings, at Eight o'clock.

May 2.—"The Wild Silks of India, especially Tussah." By Thomas Wardle, Esq. Sir P. Cunliffe Owen, C.B., K.C.M.G., will preside.

May 23.—"The Harbour of Kurachee." By W. J. Price, Esq., M.I.C.E. Sir William Merewether, C.B., K.C.S.I., will preside.

Cantor Lectures.

The Third Course of Cantor Lectures commences on Monday next, the 21st inst. It will consist of Five Lectures by W. H. Preece, Esq., on "Recent Advances in Telegraphy."

Lecture I.—April 21.

Definitions of telegraphy and electricity. Electrical effects. Sources of electricity. Economical distribution of electric currents.

Lecture II.—April 28.

The transference of electricity. Wires. Insulators. Supports. Gutta-percha, india-rubber. Underground wires and cables.

Lecture III.—May 5.

Simple telegraphy. Visual and aural signals. Telephones. Telegraphic writing.

Lecture IV.—May 12.

Duplex, quadruplex, multiplex, and harmonic telegraphy.

Lecture V.—May 19.

Automatic and fast-speed telegraphy.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. W. H. Preece, "Recent Advances in Telegraphy." (Lecture I.)

Society of Engineers, 6, Westminster-chambers, 7½ p.m. Mr. J. L. Haddon, "The Essentials which should Govern the Construction and Working of Tramways."

Royal United Service Institution, Whitehall-yard, 8½ p.m. Mr. R. Griffiths, "The Form of the Stern and the Arrangement of the Propeller in Screw Ships, in order to obtain the best effects in Propulsion."

British Architects, 9, Conduit-street, W., 8 p.m. Sir James Watson, "Improvements in Glasgow and the City Improvement Act: Origin of the Artisans Dwellings Act."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 3 p.m.

Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. Mr. R. Brown, "The System of Zoroaster Considered in Connection with Archaic Monotheism."

Tues....Metropolitan Scientific Association, 160a, Aldersgate-street, E.C., 7 p.m.

Royal Horticultural, South Kensington, S.W., 1 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. Ernst Pauer, "Schubert, Mendelssohn, and Schumann." (Lecture I.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. James T. Chance, "Dioptric Apparatus in Lighthouses for the Electric Light."

Royal Colonial, "Pall Mall," 14, Regent-street, S.W., 8 p.m. Dr. Logan H. D. Russell, "Jamaica, a Home for the Invalid, and a Profitable Field for the Industrious Settler."

East India Association, "Pall Mall," 14, Regent-street, S.W., 3.30 p.m. Mr. Robert H. Elliott, "The Impending Bankruptcy of the Soil of India."

Wed....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. J. Willis-Bund, "English Fresh-water Fisheries."

North American St. George's Union (at the House of the Society of Arts), 3 p.m.

Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Mr. George Washington Moon, "What is Poetry?"

Society of Telegraph Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. Adam Scott, "Recent Improvements in Professor Bell's Telephone."

Antiquaries, Burlington-house, W., 8½ p.m.

Thurs...Royal, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 12 noon. Anniversary Meeting.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "Dissociation." (Lecture I.)

Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.

Royal Society Club, Willis's-rooms, St. James's, S.W. 6 p.m.

Mechanical Engineers, 25, Great George-street, S.W., 7 p.m. 1. Captain Douglas Galton, "The Effect of Brakes upon Railway Trains." (Third paper). 2. M. George Marié, "Recent Brake Experiments upon the Lyons Railway." 3. Mr. Alan C. Bagot, "The Construction and Comparative Merits of the Safety Lamps generally in use." 4. Dr. J. Hopkinson, "Electric Lighting." (First Paper).

Fri.....Mechanical Engineers, 25, Great George-street, S.W., 7 p.m. Papers and Discussions continued.

Royal United Service Institution, Whitehall-yard, 3 p.m. Captain Colomb, "Broadside Fire and a Naval War Game."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m., Mr. Francis Galton, "Generic Images."

Quekett Microscopical Club, University College, W.C., 8 p.m. 1. Mr. Adolf Schulze, "A Method of Resolving the Finest-lined Diatomaceous Tests." 2. Mr. A. D. Michael, "The Reproductive System of Certain of the Acarina."

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakespeare Society, University College, W.C., 8 p.m. 1. Rev. J. W. Ebsworth, "Falstaff and his Satellites, from the Windsor Observatory." 2. Mr. W. Wilkins, "The Seasons of Shakespere's Plays."

Sat......Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Capt. Abney, "Selective Reflection." 2. Mr. C. Boys, "Some Phenomena connected with Magneto-Electric Induction." 3. Dr. S. P. Thompson, "Notes from the Physical Laboratory of University College, Bristol."

Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. H. H. Statham, "The Leading Styles of Architecture Historically and Æsthetically Considered." (Lecture I.)

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,379. Vol. XXVII.

FRIDAY, APRIL 25, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference will be held in the Rooms of the Society of Arts, on Thursday and Friday, the 15th and 16th May, 1879, on National Water Supply, Sewage, and Health, the Right Hon. James Stansfeld, M.P., late President of the Local Government Board, in the chair, assisted by the members of the Executive Committee:—Lord Alfred Churchill (Chairman of Council); Sir Henry Cole, K.C.B.; Colonel Sir E. Du Cane, K.C.B.; Captain Douglas Galton, C.B., F.R.S.; Mr. F. A. Abel, C.B., F.R.S.; Mr. T. W. Keates; Dr. Voelcker, F.R.S.; Mr. W. Hawes, F.G.S.; Major-Gen. F. Cotton, R.E., C.S.I. Papers relating to the above subjects will be read and discussed.

Programme of Proceedings.

The Conference will meet each day at 11 a.m., and sit till 1.30, then adjourn till 2, and sit again till 5 p.m., and, if necessary, meet again at 8 p.m.

Thursday, 11 a.m.—Opening of the Proceedings by the Chairman.
Papers and Discussion.

Friday, 11 p.m.—Proceedings will be resumed.
Papers and Discussions continued.

There will be an Exhibition of Mechanical and Chemical Apparatus in connexion with Water Supply, Treatment of Sewage, and Health. All articles for exhibition must be delivered, carriage free, not later than Saturday, the 10th May, 1879. Manufacturers and others desiring to exhibit should communicate forthwith with the Secretary of the Society of Arts.

Papers on any of above heads are requested.

The object of the Conference is to discuss existing information in connexion with the results of any systems already adopted in various localities, referring to the subjects of National Water Supply, Sewage, and Health; to elicit further information thereon; and gather and publish, for the benefit of the public generally, the experience gained. The introduction and discussion of untried schemes will, therefore, not be permitted. The papers accepted for the Conference will be printed and circulated at the Meetings.

EIGHTEENTH ORDINARY MEETING.

Wednesday, April 23rd, 1879; Frank T. Buckland, M.A., Her Majesty's Inspector of Salmon Fisheries, in the chair.

The following candidates were proposed for election as members of the Society:—

Allen, E., Herne-hill, S.E.
Atkinson, R. S., 57, Tredegar-square, Bow, E.
Ball, Frederick, 18, Bell-street, Henley-on-Thames.
Beard, Neville, The Mount, Ashbourne, Derby.
Bostel, Daniel Thomas, 18 and 19, Duke-street, Brighton; and 8, Golden-lane, E.C.
Carter, Robert, 15 and 16, Minories, E.C.
Chapman, W., 5, Blenheim-road, St. John's-wood, N.W.
Croal, Thomas Allan, 16, London-street, Edinburgh.
Evans, Lewis Henry, 33, Walbrook, E.C.
Fenton, Myles, 22, Parkside, S.W.
Foottit, Robert, 96, Union-road, Rotherhithe, S.E.
Gardner, C. F., 2, Dean's-yard, Westminster, S.W.
Hale, Charles George, 12, Albert-mansions, Victoria-street, S.W.
Hubbard, Egerton, M.P., 24, Prince's-gate, S.W.
Hubbuck, Edward Martin, 24, Lime-street, E.C.
Jeffery, James, 2, Pen Olver-cottages, The Lizard, Cornwall.
Marsh, W. R., Rice Mills, Bromley, E.
Morris, William, 80, Old Broad-street, E.C.
Nicholson, W., 65, Goswell-road, E.C.
Ouvry, Frederic, 66, Lincoln's-inn-fields, W.C.
Pallett, Robert Henry Charles, Theydon-hall, Theydon Bois, Essex.
Park, Charles, 99, Long-acre, W.C.
Perkins, James, 13, Water-lane, E.C.
Pilbrow, James, F.S.A., Rock St. Michael, Hastings.
Risch, C. H. G., Belvedere-cottage, Lansdowne-road, Old Charlton, S.E.
Roberts, Richard, 15, New Broad-street, E.C.
Russell, Hon. Francis Albert Rollo, Pembroke-lodge, Richmond, Surrey.
Scott, Robert, Denzel, Altrincham.
Shone, Isaac, Mayor of Wrexham.
Snell, Henry Saxon, 22, Southampton-buildings, W.C.
Stahlschmidt, J. C. L., Southey-road, New Wimbledon, S.W.
Staples, H., Pewterers'-hall, Lime-street, E.C.
Sutcliff, Robert, Magdala Works, 100, Bunhill-row, E.C.
Talmadge, John Trinder, 53, Penn-road-villas, Holloway, N.
Tamblyn, Frederick, 2, Yarmouth-villas, Kingston-on-Thames.
Townend, James H., 16, Lime-street, E.C.
Viney, Ebenezer, Upper Norwood, S.E.
Walstencroft, Thomas, 46, Ludgate-hill, E.C.
Watkin, Henry Samuel Spiller, 2, Nelson-villas, Stoke, Devonport.
Way, T. E., 9, Argyll-road, Castle-hill, Ealing, W.

The following candidates were balloted for and duly elected members of the Society:—

Bullock, Thomas A., 11, Old Broad-street, E.C.
De Chaumont, Francis Stephen Bennet François, M.D., Woolston-lawn, Southampton; and the Army Medical School, Netley, Hants.

Giffen, Robert, 44, Pembroke-road, Kensington, W.
Huson, Charles W., 5, York-buildings, Dale-street, Liverpool.
Williams, Frederic Bessant, F.S.S., 2, Ludgate-hill, E.C.

The paper read was—

ENGLISH FRESH-WATER FISHERIES.

By J. W. Willis-Bund, M.A., Barrister-at-Law,

Chairman of the Severn Fishery Board.

A great deal of attention has been directed to our fisheries during recent years, and various measures have been proposed to place them in a more satisfactory state. It is admitted by all that the fisheries offer a food supply which, in these days of high prices, we cannot afford to neglect, and the question that all interested in the fisheries have tried to solve is, in what way to render this supply of food most available. Unfortunately, the matter does not rest here, otherwise the question would have been long ago satisfactorily answered. Each person has, as a rule, some private interest in the fisheries, in addition to that of the general public, and thinks that the advancement of his own private interests is the only true solution of the matter. These interests are nearly always antagonistic, and so the fishery laws are a compromise, not only between the interests of the public, as concerned in the food supply, on the one hand, and the interests of private property on the other, but also between different classes of private interests; and it is not too much to say that the conflict of different private interests is the great cause which retards the development of the English fisheries. Speaking broadly, on every river there are two great classes, the upper proprietors, in whose waters the migratory fish are bred, the lower proprietors, in whose waters the migratory fish are caught. No river can really flourish unless these two parties work together, and it is the exception to find any English river where such is the case. Each proprietor applies —

> "The good old rule, the simple plan,
> That they should take who have the power,
> And they should keep who can."

And between the fish that the lower proprietors legally, and those that the upper proprietors legally and illegally take, the stock becomes so diminished, that the river only furnishes a fraction of its proper yield of fish.

As if these two antagonistic elements were not sufficiently bad, on some rivers, a third class, who call themselves the middle proprietors, have sprung up. These persons, who may be described as piscatorial Ishmaels, seem to think that the whole duty of the upper proprietor is to breed fish for them to catch, and the whole duty of the lower proprietor to allow fish to pass up to them to be caught, while their own duty is never by any chance to allow a fish to escape them. They contribute nothing to the stock of fish which they devote their whole energies to lessen. With such a state of things, it is not, therefore, wonderful that the English fisheries do not increase as they ought to do, it is only wonderful that they are able to exist at all amidst such suicidal steps.

I propose to-night to call attention to the present position of the fresh-water fisheries, and by the term fresh-water I understand not merely the fish comprised in the recent Fresh-water Fisheries Act, but all fisheries other than sea fisheries.

The fisheries cannot complain that they have been neglected by the Legislature. Fish has always been a favourite subject for legislation. The Royal Commission of 1860 stated as one of the causes that retarded the development of the fisheries, the confusion and uncertainty of the law, and the multiplicity of statutes on the subject. So they repealed all the full general Acts, and inaugurated a fresh departure.

In the 18 years since 1861, nine* Acts of Parliament have been passed, and the period of finality in fishery matters appears as far off as ever. Hence, the confusion and uncertainty of the law is almost as great now as it was in 1860. If it were not for the rule of law that "Ignorance of the law excuseth no man," convictions for offences against the fishery laws would be of rare occurrence; indeed, it is not an unknown thing to find Fishery Boards themselves guilty—unwittingly guilty—of a breach of the law. To add to the confusion of the statute law, Fishery Boards are allowed to make bye-laws for "the better protection, preservation, and improvement of the fisheries within their districts."† As the different Boards by no means take the same view of what is for the better protection of the fisheries, very different bye-laws have been made, and it is often difficult, not only for a stranger, but for a fisherman, to know whether he is or is not breaking the law. Thus, in the Bristol Channel the division between the Severn and the Wye districts is an imaginary line drawn down the centre of the Channel. In the Severn district, fishing begins in February; in the Wye, not till later. So that, according as a man is standing to the right or left of an imaginary line, he is or is not guilty of an offence. Again, the inland boundaries of the different fishery districts have never been defined; a person carrying a gaff at a time it is legal to use it in one district and illegal to do so the next, is or is not guilty of an offence, in accordance with the view the Court takes as to which fishery district he was in. It would be easy to multiply such instances as these. It is unnecessary to point out what a door they open to the infraction of the law.

With the exception of salmon, trout, char, and eels, there has not been until this year any close season of general application for fish. Such a close season was introduced by the Fresh-water Fisheries Act, 1878 (41 and 42 Vic. c 89). By that Act all fresh-water fish that do not migrate to the open sea, other than pollan, trout, and char, are protected between the 15th March and the 15th June. But this Act has fallen under the original sin of fishery legislation exceptions, and these exceptions have eaten away the Act. Owners of private fisheries may destroy fish. Fish may be taken for scientific purposes. Fish may be taken for bait. The practical result of the Act may be seen by a reference to this last exception. Before this year all the anglers for white fish used to use baskets or bags for carrying the fish they caught; now, although the close time is in existence, the angling goes on

* 24 and 25 Vict. c. 109, 26 Vict. c. 10, 28 and 29 Vict. c. 121, 33 and 34 Vict. c. 33, 36 Vict. c. 13, 36 and 37 Vict. c. 73, 39 and 40 Vict. c. 19, 39 and 40 Vict. c. 34, 41 and 42 Vict. c. 39.

† 36 and 37 Vict. c. 73, s. 39.

as before, only the anglers, instead of baskets and bags, take large tins with them, keep the fish alive in the tins, and say they are taking them for bait. A water bailiff reported to me last week that at one place he counted no less than ten persons angling for bait, each of whom had taken a considerable number of fish. The chief fish protected by the Act are pike, roach, dace, chub, carp, tench, bream, barbel, ruffles.

It is a great question how far it is desirable to protect these fish in all our rivers. In the east of England, and in those parts of the country where no other fish are found, it may be well to do so; but in any river which will produce better fish, the policy of protecting the coarse fish is very questionable. In most salmon and trout rivers, one of the great objects of the Conservators is to keep down the pike and coarse fish, on account of the destruction they cause to the young fry. The number of young trout or salmon a pike will consume is incredible, and it is not too much to say that the thousands of artificially bred young salmon that are turned into our different rivers by benevolent pisciculturists, if the pike are numerous, do not suffice to feed them. And it is not only the pike that feed on the fry of fish; any one who has spent a hot summer's day on the banks of a river will have noticed the shoals of fry in the shallows, and if he looked close enough will have seen lying outside in the stream a large chub or perch intently watching them; a better example of the rule in the Declaration of Paris, that a blockade to be obligatory must be effective, cannot be found; the water is too shallow for the chub to get at the fry; as long as he lies there they cannot get out with safety; at last they determine to try to escape, they go as far as they dare, see the chub, and turn back. At length they slowly go out into deep water, and swim as hard as they can, but the chub is too quick for them, and a certain number find their way inside the chub. Nothing can be more amusing than to watch these scenes; how far they are desirable for benefit of the fisheries is another affair.

The question seems to resolve itself into this. A river will only support a certain number of fish; if more than the proper quantity are found, the fish decrease in size and deteriorate in condition. As, therefore, an unlimited stock cannot be kept, what is the best kind to keep? You cannot have all, and you can only have some by destroying the others. If you cultivate coarse fish, you destroy your trout and salmon, and it is a question which is best to preserve. The answer of an angler will not be doubtful for a moment, and I think that the general public would prefer as an article of food trout to chub or pike. I am therefore unable to join in the unqualified chorus of praise that the Fresh-water Fisheries Act has received. I quite agree that no fish should be taken in close season. It is the interest of the public that the fish they eat should be brought into the market in the best possible condition, but I do not think that an Act, which makes the preservation of coarse fish compulsory throughout the kingdom, is one that is calculated to improve our fisheries. Take the case of the Thames. The great ambition of a Thames angler is to catch a Thames trout, but a Thames trout is about the most valuable fish there is. It costs the angler quite £1 a pound. Notwithstanding the protection the Thames receives, the number of artificially bred trout that are yearly turned into it, the restriction as to the size of the fish that may be taken, there are very few Thames trout to be caught, and it is given to very few to catch them, and when the event takes place, it is announced in the newspapers as almost as great a feat as catching a Zulu or taking an Affghan fort. Why is this? Simply because of the number of coarse fish in the Thames. The Thames pike must live—or I might say I don't see the necessity for it, but they will live—and so the Thames trout are scarce.

I have endeavoured to ascertain what is the market value of the coarse fish in this country; but I have quite failed to get any reliable data. That a large quantity is sold, both locally, to the residents on the banks of the different rivers and in the public markets, there can be no doubt, and I believe that large quantities are also imported, but what the amount is seems almost impossible to ascertain. As far as I can find out, the retail price varies from 6d. to 4d., or 3d. per lb. As the price of trout or salmon would seldom, if ever, be less than 10d., it is obvious that it is for the interest of the owners of the fisheries, even if it is not for that of the public, to encourage trout to the exclusion of coarse fish.

It is equally difficult to ascertain the modes in which the coarse fish are taken; although we hear of a good many being taken by angling, I think that those taken by that means are but a very small proportion to those taken in other ways. Nets, traps, night lines, trimmers, account for the largest proportion; but as these modes of fishing are very often illegally conducted, those who practice them are naturally unwilling to say what fish they take. One great defect of the Fresh-water Fisheries' Act, to my mind, is that it does not attempt to regulate the mode of fishing. The restriction of illegal and improper modes of destroying fish is quite as important as the experiment of a close term.

One very important part of the fresh-water fisheries are those for eels. In the autumn of the year, in most rivers the eels migrate in considerable quantities to the sea. In the month of June, if the water becomes muddy, the eels begin to move, and continue at intervals until the end of November, the great quantity, however, descend in September and October. In their progress to the sea, they are mainly captured in two ways, first by fixed traps at mills, and secondly by nets fixed in the middle of the stream. Eels, when migrating seawards, swim deep at or near the bottom of the river, and always go down the main current, the eel nets are accordingly set in the current, and fish very deep. These nets take a very large quantity of eels; indeed, when we see them fishing, the wonder is any eels escape; but as the nets are put one after another, at short distances apart, and as the net lowest down the stream often has a good catch, it is clear that a larger number get by than would be supposed. It is difficult to say what the take of eels is; a good night's fishing would be about 3 cwt. a net; sometimes much more are caught, oftener much fewer. Fishermen all say that the take of eels has fallen off greatly of late years. I believe it has, but not so much as is imagined, and fishermen always look back to the take of

their youth, with the enchantment that distance lends to the view. I should think that the average take of eels would be a cwt. a night to each net; but it must be remembered that nets can only be used when there is a fresh on the river, that it is almost useless to fish for them on a fine moonlight night, or with a falling water, so that the times when eels are caught are extremely limited. If we take 14 nights in the year as the average, and a cwt. to each net, it will not be far wrong. I have not been able to arrive at any data as to the eel fisheries except in the Severn Fishery District, and here I should think that from 30 to 35 tons of eels are taken annually. Eels are sold at about 6d. a pound, taking great and small alike, and this would make the value of the eel fisheries of the Severn district some £2,000 a year. I think I shall be understating the figures if I put the eel fisheries of the country at ten times that sum, or £20,000 a year.

It is admitted on all sides in the Severn that the eel fisheries are declining, and that in parts of the river in which eels formerly abounded, they are now so scarce as to make the fishing for them not pay the expenses, and this is attributed to two causes—(1) that the engines used for taking eels have increased in the lower parts of the river, and (2) that the fry of the eels are destroyed wholesale. I am not inclined to adopt the first reason. I think any increase in the number of engines lower down is met by the decrease in the number above, and that the one may fairly be set off against the other. Of course the eel fisheries are now more valuable than they were. Eels are a fish that travel well, and the demand for them in London and the other large towns, and in the manufacturing districts, is unlimited. The demand for eels always exceeds the supply, and this is mainly so because the eel is essentially the poor man's fish; I do not mean to say that the upper classes do not appreciate a dish of well-cooked eels, but the great consumption of eels is among the poor. Any person who walks through the slums of any large town will notice that the lower the neighbourhood the more frequent the notice to be seen in the eating-houses of stewed eels. I think it may be affirmed that there is no fish which the poor look on as a greater luxury than the eel. It is, perhaps, from the eel being the poor man's fish, and that noble lords and honourable gentlemen would not condescend to catch eels, that the eel fisheries have not received the care and attention they should do. It is true that by chance a recent statute* fixes a close season for eels from Christmas to Midsummer, but the close time is fixed, in the interest not of eels, but of salmon. If the working classes ever take part in making fishery laws, the eel is the first fish they will protect. The second cause I have mentioned, the capture of the young fry of the eels, is, to my mind, the cause of the decline of the eel fisheries. In the spring months, March and April, millions of young eels ascend the rivers from the sea. Unlike the descending eels, the ascending elvers, as they are called, swim on the top of the water close in to the shore. Their number is legion. No one who has not seen the long dark line moving up the river would believe in the enormous power of reproduction the eel must possess. It is one of the most curious sights that can be witnessed to see elvers going up the river; nothing seems to stop them; they go onward and onward, over weirs, rocks, or any obstruction, until at last they become dispersed among the brooks and tributaries of the main river. Of the millions that attempt to ascend, very, very few ever reach their destination, gulls; fish, and other natural enemies destroy them, but the worst enemies are the fishermen who go out elvering; the quantity they catch is enormous, with a scoop covered with canvas they literally ladle them out of the river. These fish find a ready sale. Elvers cooked are said to be delicious. These are to the dwellers on the banks of the river what whitebait is to the dwellers in London. I suppose it is impossible for any living creatures to be subjected to systematic destruction and not to decrease in number. This is the case with the eel; as the capture of elvers have increased so have the eel fisheries diminished, and if the capture of elvers goes on, the ruin of the eel fisheries is only a question of time.

* 36 and 37 Vict., c. 71, s. 15.

In 1873, the Legislature prohibited the capture of elvers*, and the fishermen who caught them raised an outcry that one of their means of support was taken away. The great centre of the elver fishing is Gloucester, and the members for Gloucester took up the cry on behalf of their constituents, the poor fishermen, and, at their instance, the law was modified, and the capture of elvers allowed during the month of March and part of April.† The eel, as I have said, is the poor man's fish, and the working classes of the black country, of Staffordshire, of Birmingham, the great consumers of the grown eels, were not able to make their voice heard. Had the members for those places been as fond of eel fishing as they are of salmon fishing, no measure that allowed the inhabitants of one locality to kill the fry that supplies the whole river, would have had a chance of passing.

There is one other cause, which, while it tends to make the eel fisheries not so productive as they formerly were, tends also to preserve them from extinction. I have already stated that the eel fisheries can only be carried on when there is a fresh on the river. Modern farming and land drainage have, in various ways, affected our water supply and fisheries, but none have been so affected as the eel fisheries. In the old times, when a fall of rain created a slight rise in the river, the eels came down after each fall, and all, or most of them, were caught. Now, these gentle freshes—or the dribbling waters, as the fishermen call them—which are the ideal of an eel fisherman, hardly ever occur; a rapidly rising water, a flood, and it is all over. If the water is too high, or rises too rapidly, the nets cannot fish, and the eels pass by uncaught seawards. Thus the result of the land drainage is to limit the opportunities for catching eels, and hence to render the fisheries less productive. I do not think that this accounts altogether for the falling off in the fisheries. I believe that that is to be attributed mainly to the capture of the elvers. But I do think that this is a cause that, while it is true, it averts the evil day when the eel fisheries will be extinct, yet should be taken into account when the question of their productiveness is discussed.

* 36 and 37 Vict., c. 71, s. 15. † 39 and 40 Vict., c. 34.

I have left until the last the most important of all the fisheries, those for salmon. Salmon have always been the favourite fish for legislation and law, and although a lawyer myself, I am bound to say that I think one of the great causes why the salmon fisheries of the country are not more productive than they are, is that they suffer from too much law. So far as salmon fisheries are concerned, the rivers in which salmon are found have been parcelled out into fishery districts, and placed under the management of local boards. And this has been carried to an extent that is rather ludicrous. Boards of Conservators exist for districts where no watchers are employed, no licences issued, no salmon caught! What is the *raison d'être* of these Boards it is hard to see. In some other districts there are far more members of the Board than there are salmon taken. But although there are these and other anomalies, I believe that, on the whole, the Boards of Conservators work fairly well. In all there are 42 Boards of Conservators, with an income of about £7,000 a year derived from licence duty. Having regard to the very large area which these Boards have to look after, the wonder is not that they do so little, but that, with such small means, they are able to do so much. It is something to the credit of the Board that, having an area of above half England to look after, and only 216 men wherewith to do it, they were able, in 1877, to obtain 286 convictions for offences against the fishery laws; of course these convictions are but a small proportion of the number of offences actually committed, but I believe that, except in certain districts, where, from various local causes, the law is set at defiance, most of the serious offences against the Fishery Acts are detected. It is, doubtless, true that in the lower fisheries the weekly close time is not always accurately observed. A fisherman's watch, if he has one, has a convenient habit of stopping at 11.30 on Saturday morning, and, in the upper waters, Welsh farmers and north country shepherds catch a fish when it is spawning, or when they can; but on the whole, I believe that the law is fairly observed, and it is a question if the law was more strictly enforced would it be observed any better than it is. As things are at present, the preservation of fish can only be carried on if the law is fairly popular; once let it become unpopular, and a far greater outlay in protection will not produce any greater number of fish.

The returns as to the water bailiffs employed by the different Boards give some curious results. During the four years ending 1877, two Boards, the Otter and the Frome, have employed no watchers. For the last three years, ending 1877, the Avon, Brue and Parut, has not had any watchers. In 1877, eleven districts employed only one man each (Kent, Conway, Cleddy, Oganore, Taff, Rhymney, Camel, Fowey, Axe, Frome, and Sussex Ouse). Only nine districts employ 10 and over. The Ribble, 10; Towey, 10; Coquet, 10; Tyne, 11; Esk, 12; Rother, 12; Dovey, 12; Usk, 14; Severn, 24; Wye, 32.

If we test the way the water bailiffs do their duty by the number of charges for infraction of the fishery laws they bring, it would seem that the activity of the watchers varies greatly in the different districts. In 1877 no less than 13 districts were in the happy state of having no infraction, at least no detected infraction, of the law. These districts were the Conway, Cleddy, Rhymney, Avon, Brue, Fowey, Tamar, Exe, Otter, Axe, Frome, Avon, and Stour Rother, Kentish Stour. The 32 water bailiffs of the Wye only detected 13 cases, and the 24 of the Severn 14, while the 11 of the Tyne detected 75, the 14 of the Usk 38, the 10 of the Towey 31, the 5 of the Teify 26, while the 12 of the Rother did not detect a single offence. Indeed, the Rother seems a very happy district. It has never had less than 12 water bailiffs during the four years ending 1877, and during those four years no prosecution against the Salmon Fishery Acts have ever been undertaken. This was a state of things that it was difficult to understand, and it can only be accounted for by the fact that no salmon exist to be caught.

It is the fashion for local Boards to run into debt; I am glad to say on this point fishery Boards are an exception. On the 31st December, 1877, out of the whole number, only three were in debt, and the whole of the debt of the three was under £300, of which one Board owed more than half. With the exception of three that have no revenue at all, all the others had a balance in hand, varying from £496 11s. 11d. in the case of the Ribble, to 6s. in the Fowey. It would seem that, therefore, on the whole, the Fishery Boards are fairly prosperous.

We must look now at the other side, and see what results these Boards have produced, what amount of food have they supplied to the public. Here we are met by the same difficulty as under the Fresh-water Fisheries Act, the impossibility of obtaining accurate returns. Some of the best rivers in England never make any return at all, while those that do make it, base it to a great extent on guess-work; it is, however, possible to arrive at some estimate of the fish taken. In 1877, in the Severn, 18,400 salmon, weighing 115½ tons, were caught; in the Tyne, 41,300, weighing 495,600 lbs.; in the Dart, 7,400, weighing 76,000 lbs.; in the Ribble, 6,191, weighing 74,292 lbs.; in the Clewdd, 150, weighing 3,420 lbs. This gives for the five rivers a total of, in round numbers, 75,000 fish, weighing 904,000 lbs. I think that these figures are, as to weight, rather high, as in all probability the 75,000 would not average over 10 lb. a-piece, and as to fish rather low; but taking it that the product of these five rivers is fairly stated at 1s. per lb., it represents a money value of £37,500. In the rivers that give no returns, the Eden is certainly more productive than the Ribble, and the Dee probably produces more salmon than either, and the Clewdd is by no means the best Welsh stream. If we assume that Wales, the Eden and the Dee, yield as much as the five rivers I have mentioned, and, for the other rivers in the south and on the Yorkshire coast, add 15,000 fish at 10 lb. each, we shall not be far wrong, and this gives a total of 165,000, weighing 1,650,000 lbs., and representing a money value of £82,000. I think that these figures, especially the last, as to money value, are under the true figure. There is another way at which to get at the money value of the fisheries, namely, as to how much per cent. the license duty represents. I have made several calculations upon the subject, and the conclusion at which I arrive is that the license duty represents a tax of 6 per cent.; of course, I am quite aware that this is very conjectural, but I think

it is not very far out. If this is right, then, taking the license duty at £7,000, the value of the fisheries would be, in round numbers, £110,000; this may be too high, but I do not think we shall be wrong if we say that the salmon fisheries are worth at least £100,000 a year.

In some respects, this is a very satisfactory result of the working of the Salmon Acts. The late Mr. Ashworth made a calculation of the value of the salmon fisheries in 1861, and put them at £30,000; if, in 20 years, they have trebled in value, good progress has been made. But have they trebled in value? I very much doubt it. That they have increased in value is doubtless true, but the amount of increase is another question. I think Mr. Ashworth's calculation of the fisheries was based on insufficient evidence, and greatly understated the case. I am sure it was so on the river I know best—the Severn. I believe it was so also so on the Tyne, the Dee, and the Eden, to say nothing of the Welsh rivers; and, if I may say it, great as was Mr. Ashworth's knowledge, he was not the best person to make the calculation—certainly not for the Severn. When he made it, he was on the eve of purchasing large fisheries on the river, and it was not, therefore, his object to represent those fisheries at their maximum value. I should certainly say that the salmon fisheries in 1861 were worth at least £50,000; and, if, in twenty years, the salmon fisheries have even doubled in value, it speaks well for the work of the fishery officials.

If the matter stood here, I should feel very hopeful of the future of the fisheries; but I regret to say, there are one or two other points that put a different complexion on the case. The best way to see this is to look from the number of fish caught to the different modes by which they are taken. Practically, the modes by which salmon are taken are three—rod and line, fixed engines, and nets. More than two-thirds of the fish are taken by nets; the quantity taken by rods is very small indeed. As a rule, the rods represent the upper proprietor, who breeds the fish; the nets, the lower proprietor, who takes them. At first sight it would seem that the public, whose interest is in the food supply, do not care by what means the fish are taken as long as they reach the market in the best possible condition; but there is one fundamental proposition in Salmon Fishery management, the prosperity of a river depends upon the prosperity of its rod fisheries, if they fail, the general prosperity of the river fails also, and therefore it is that the public are, in fact, more interested in the rod than in any other fisheries. Unfortunately, the rod fisheries are the class that have not improved since 1861 in the same, or in anything like the same degree, as the net fisheries. Indeed, it is doubtful if, except on one or two rivers, the rod fisheries have even improved at all. As the fish have increased, so have the means of capture increased, and the result is that over-fishing, which was admitted by the Commissioners of 1861 to be one of great causes of the falling off of the fisheries, instead of being checked, has increased. As the fish have increased, so the nets and engines that a fish has to pass in his passage from the sea to the upper water have increased largely. I often hear it mentioned, as a sign that the river is improving, that such and such a person has determined to use his fishery that has been disused for years. I am bound to say I hear such news with fear and trembling. It is one less chance for a fish to reach the upper waters.

The question as to the further development of the salmon fisheries rests on this—the proper adjustment of the relations between the rod and net fishermen, or, in other words, between the upper and lower proprietors. The matter is one that must soon be dealt with if our fisheries are to go on prospering. Much of the dissatisfaction that exists is the natural reaction from the golden dream that all riparian proprietors formed in 1861 and the subsequent years, that they had only to own water adjoining a river, and they would, ere long, have valuable salmon fisheries, and some persons generously sacrificed their trout and grayling fisheries in order to increase the breed of salmon. They have found their hopes illusory; the salmon have not come except in the close season, or as kelt to eat up the trout; the trout fisheries have deteriorated, and the upper proprietors have found themselves bitterly disappointed. The result is a storm of discontent, the first fruits of which we have seen on the Wye. I am always averse to suggesting remedies unless I am asked, but usually, when I am speaking on the subject of salmon fisheries, I have to hold my tongue as to what I really think, and to act as a sort of buffer between two conflicting interests, the partisans of each of which equally blame me if I say anything to harm the other. To-night, however, I can say what I really think, and I firmly believe that unless a stop is put to new fisheries, new nets, especially in fresh water, springing up every year, no great increase will be found in our fisheries. A right a man never exercises, and has never exercised, is not of much value to him, and if Parliament enacted a law to-morrow that only such nets as had been used in the fresh water during the last four years—as they did in 1865 with regard to the fixed engines in tidal waters—more would be done for the fisheries than has been done since 1861. As it is, the upper proprietors are losing heart, they say they are tired of breeding fish for others to kill; and unless some measure is passed in the spirit of what I have mentioned, I fear that the salmon fisheries, instead of increasing, will decrease. It is idle to hope for any good from any half measures, such as the addition of a few hours to the weekly close season, or a month to the annual close time. The prohibition of all netting in fresh water is the measure that would do more for the fisheries than anything else; that is, however, practically impossible, and so we must be content with the prohibition of new nets.

Time will not permit me—nor, perhaps, is this the place—to speak of the other causes that retard the development of the fisheries. Pollutions of themselves are a sufficient subject for a series of lectures, and they are, no doubt, one of the most pressing evils that the fisheries have to contend with. Other minor causes there are, but, really, they all sink into insignificance before the great evil of over-fishing.

The fisheries seem to me to be now at the turning-point of their history. If the policy of 1861 is carried out, there is no reason why they should not be developed to almost an unlimited extent; but it must be carried out in no half-hearted or lukewarm

spirit. The improvements that the measure of 1861 brought about are well-nigh spent, and it depends very much on whether another step in advance is now taken whether the fisheries increase or decrease. A new departure has been arrived at by the Fresh-water Fisheries Act. No longer have we merely to consider the question, shall we have salmon or not in order to ensure protection, but what fish is best adapted to the river, and, having once determined on that, then to devote all the available power to cultivation of that kind of fish.

The real praise of the Fresh-water Fisheries Act is not that it protects coarse fish, but that it allows a Board of Conservators to be formed for rivers that do not contain salmon, and this enables every river to have the benefit of protection, and to protect the fish that are best suited to it. It is dangerous to prophesy, as prophets are always wrong, but I venture to say that, in proportion as this fact is recognised, as this Act is used as a means of affording protection to unprotected waters, not as antagonistic, not as a supplement to the Salmon Fishery Act, but to preserve rivers where no protection now exists, to such extent will it succeed. It all depends on how it is carried out, and I have sufficient confidence in the good sense of Boards of Conservators, and of the good sense of my brother anglers, that they will work together to promote the common object, an increase of fish, whether salmon, trout, or white fish, and thereby an increase not only of their own sport, but also of the food supply of the country.

DISCUSSION.

The Chairman, feeling indisposed, had to leave the room before the conclusion of the lecture, and the chair was taken by Mr. G. T. C. Bartley.

Mr. Cooke said in Hampshire there was a large reservoir made by a former Bishop of Winchester, but of late years it had become more and more muddy, and there was a great difficulty in keeping fish there. In Scotland, also, he saw that the rivers had been poisoned by manure coming down from the land, and he did not see how this difficulty was to be avoided. But there was another evil, which was very prevalent in Cornwall. He knew of a large pool, called the New Pool, in which there had been trout since the time of Edward III., for there was an estate held on the tenure of providing the Duke of Cornwall with fishing tackle when he required it, but he understood that the fish there had been almost destroyed by the refuse from the mines. He thought it would be a good thing if the Serpentine were stocked with fish, as he believed Mr. Willis-Bund suggested the other evening in a letter to the *Globe*. It was a great pity that the Thames should be worse off for fish in the time of Queen Victoria than it was in the days of Queen Elizabeth. To show the former abundance of fish, he might mention that he was informed that some years ago a gentleman bought a salmon weighing 40 lbs. for 5s.

Mr. Hale thought this question ought to be treated from the point of view which effected the good of the people, especially considering that we had to obtain two-thirds of our food from abroad. He did not see why legislation could not be devised which would make salmon as cheap as it used to be, and thought something might be done if the Society took up the subject.

The Rev. Mr. Vaughan said it occurred to him that Mr. Willis-Bund had dwelt too exclusively upon fishing as the amusement of gentlefolks. Mr. Mundella, he believed, introduced his Bill in the interests rather of the poor fishermen than of rich people, and he hoped that in the discussion the interests of the poor fishermen in London, Birmingham, Sheffield, and elsewhere, whose only out-door amusement was on the banks of the rivers, reservoirs, ponds, or canals, would be considered. It seemed to him to be rather a selfish thing for a body of gentlemen to meet together and discuss a Bill such as Mr. Mundella's, and think only of themselves. He, as a clergyman, naturally regarded fishing from the moral stand-point. He considered that an interest in fishing was a very great thing for the working man, and that they should try as far as possible, in the interests of science, to encourage it. He trusted therefore that the interests of those who did not belong to their own class would be remembered. There were many there who had been accustomed to trout, grayling, and salmon fishing, and who in their own interests were very much disposed to underrate the interests and amusements of others. He was a coarse fisher, as well as trout and grayling, and he thought they ought not to think entirely of fine fishing and neglect the coarse.

Mr. Francis said it had been his pleasure on many occasions to hear various papers read on fishery subjects, but he must say he did not think he had ever heard a better paper than the one he had just listened to. He had the warmest sympathy with many of the views expressed by Mr. Willis-Bund, especially when, referring to the Wye, he said that the fisheries had been over-legislated for. Before there was any legislation, he knew the upper portions of the river—which were now almost in a state of rebellion—when they were most admirably stocked with salmon, and afforded fine sport to the rod fisher. On one occasion, not at the best time of the year, he had hooked six salmon in one afternoon, and when you had a fishery like that it was rather hard on the proprietor to find that this legislation, which was to do so much for him, had done nothing at all, but had almost ruined his fishery, for the fisheries now were infinitely worse than they were before any legislation took place. Mr. Willis-Bund, referring to the Tyne, said he did not think the increase there had been so great as it was reported, but in that he did not think he was correct. The great thing which made the Tyne increase, was the abolition of an impassable weir at the mouth of the river. When that was accomplished there was a tremendous rush of salmon, and in two or three years the increase was something enormous. But as the salmon increased, so did the nets, and off the mouth of the Tyne it was nothing uncommon for nets to be hanging for almost a mile in extent, so that the stock was very greatly reduced, and the Tyne had now gone back very much from the prosperity which it seemed likely to have. With regard to pollution, he might mention that when he was in Cornwall, as a boy, the New Pool which had just been referred to, was a charming lake, about three miles round, of clear crystal, with beautiful trout, but the last time he saw it, it was like a lake of blood with water from the iron mines. With reference to pollution generally, something must surely be done sooner or later to put a stop to it.

Mr. J. Lloyd said they were all very much indebted to Mr. Willis-Bund for his paper. His own knowledge of the last river he alluded to was perhaps more recent than Mr. Willis-Bund's. He might mention that last year his brother took five or six salmon a day in the River Wye, and on some occasions ten or eleven. He knew as a fact that the truth was not always told with reference to the pollution of rivers. He happened to have been lately concerned in a case where a river was greatly polluted by sewage. The Board of Conservators of the river declined to put the law in force; the Sanitary Board and the riparian propriotors also refused to do so, and it was left to him to beard the whole corporation of the city, although the river was poisoned for a mile of its course. Then there was another part of the same question which had not been mentioned.

In 1856, lead mines were opened at the head of the River Wye, and for about 25 miles it was like a desert. The grass on the banks was dead, and there was no food for the fish. There were laws to prevent this, but they were not put in force. He did not agree with Mr. Willis-Bund as to the eel fisheries. He believed that that gentleman was in opposition to the fishery inspector who came down to Gloucester and made inquiry whether the fry of eels should be protected or not for that particular time. At any rate a clause was put into the Act of 1873, which had to be repealed. He must say, however, that the capture of eels in some rivers was very much neglected. In one which he knew, a large mass of eels descended from the sea, and not a millionth part of them were caught. It was difficult to catch them with nets, because it was a navigable river, and he thought in such cases facilities should be given for capturing them by fixed engines. Mr. Willis-Bund was rather hard on some fishermen in some of the rivers, but perhaps he had only heard one side of the story, and he certainly had not stated the case of the middle fishermen quite so fully as it might be. The essential thing for the increase of fish was to make the water pure, and to keep it pure, and let no one contaminate the stream. He desired to lift up his voice in favour of carrying out the law, and abolishing this grievance, which was fatal to the existence of fisheries altogether, and he was sorry to say he found in his own neighbourhood that the local authorities were very weak in enforcing the law, and so were the authorities at Whitehall.

Mr. Bagot said he had just come from the Ribble; and he must say that in that district the Fishery Act worked very well. There were a large number of colliers there locked out, but there was not a case of fishing in the close time. The universal opinion was that it was a good Act, and that if the landowners would observe it, the whole of the population would also. As a mining engineer, he had seen a great deal of pollution, and there was not the slightest excuse for it, particularly in the mining districts, because there were almost always canals which would be all the better for receiving the water. The evil was, that very often the persons who ought to put the law in force were interested in the colliery which polluted the river. In his own colliery, which polluted the Trent, he brought the matter before his proprietors, and they said at once they were perfectly willing to pump into the canal if the canal company would receive the water. They had polluted the Trent for 20 years, and it had never occurred to them to ask the canal company if they might pump the water into the canal, which was 600 yards nearer to them, but when the engineer was referred to, he was very glad to have the water. He was perfectly certain, if owners of land were willing to abide by the Act themselves, and not to fish in close time, those who rented the water from them, either as private persons or angling societies, of which there were a great many in Staffordshire, would also be prepared to do so. A great many people who owned water gave verbal permission to fish, but it should always be a written permission, with the provisions of the Act printed upon it, and if those provisions were broken it should be cancelled. Of course the Act had loopholes in it, every Act of Parliament had, and sometimes they were very useful, and these were not so great but that the Act might be enforced.

Mr. T. Spreckley thought Mr. Willis-Bund had commenced at the right end, and had gone to the bottom of the matter, when he told them plainly that unless efforts were made by anglers, and all interested in the question, the fisheries would not go on improving as they hoped they would. He had been under the idea that Mr. Willis-Bund was all in favour of salmon and trout—and he himself would do anything in his power to get salmon and trout into the Thames, but he feared it was impossible—and he was much pleased at the remark that they should find out first what fish would succeed best in any water, and then put that fish in there and protect them. If the Society of Arts would take up the matter, he was sure it would find people who had such a love of angling that it would be well supported, the whole question might be gone into, and a satisfactory Bill brought forward; but it must go on the principle of giving and taking, not letting any one class have it all their own way. If this were done, it would be taken up, not only by gentlemen but by the poor man who went fishing on his Saturday half-holiday. There were something like a hundred clubs in London, and they would all support a good measure. He knew a water in the neighbourhood of Nuneaton, 100 or 200 acres, which at present was totally neglected, but if the matter were properly represented to the owner, and he were shown that in two or three years the fish might be increased 30 or 40 per cent., no doubt he would take measures for the purpose. In that way he might give pleasure to thousands, and he was convinced that even the poorest, if put upon their honour, would conform to the regulations.

Mr. Jardine remarked that if the views put forward by Mr. Bagot were carried out, it would be one of the greatest calamities which could befall the country in regard to the supply of fish. The canals were the greatest nurseries of fish, and there were in this country about 4,000 miles of canals, admirably adapted for the growth of white fish, from roach or gudgeon up to pike. If it once became the practice to discharge the refuse of collieries and chemical works into these canals, the fish would soon be killed, which would be a great loss, putting aside altogether the question of sport. In the neighbourhood of Sheffield there was a canal where people came by thousands to fish, and got good sport, and the same thing occurred in many other places. One of the great advantages of Mr. Mundella's Bill, was that it took the canals under its supervision, and in the course of a very few years, if they were rigidly looked after, they would produce more sport and more fish than the whole of the rivers together. The canals, even in the worst seasons, seldom or never got out of condition, and you could get good sport in them when you could do nothing on the rivers.

The Chairman, after expressing his extreme regret that he should be called upon to fill that position, owing to the indisposition of Mr. Buckland, said that he himself knew nothing of the subject technically, but it was one in which all were deeply interested, both as a question of food, and as a recreation for the masses. He was glad to hear the remarks about the poor man's recreation, for he did think this was one of the most important points to be considered, and though he should be glad to see any improvement in the condition of the fisheries, he should have great doubts about its value if it interfered with the healthy recreation of thousands in our large towns. As a question of food supply, this was a matter of great importance, because if more fish could be produced in our rivers, they would take the place of a certain amount of meat, and reduce our bill to America. We sometimes blamed the farmers for not getting the most out of the lands, but it was equally reprehensible not to get the most out of the rivers. The totals which Mr. Willis-Bund had given did seem very small compared with the food which might be produced. Associated with this subject was that of the purity of our rivers, which the Society had been very carefully considering during the last year, and he hoped the two things would work well together. He concluded by proposing a vote of thanks to Mr. Willis-Bund.

The vote of thanks having been carried,

Mr. Willis-Bund, in reply, said he had prepared the paper somewhat in fear and trembling, because he knew from bitter experience that fishery questions were rather

calculated to cause difference of opinion, but he thought it was an opportunity to be able to state what his views of the question were, so that if they were worth anything at all they might come before the public. The question of river pollution he thought lay a little outside of fisheries, and therefore he had not dealt with it. He quite agreed with what the Chairman had said, and hoped they would find the working classes taking more and more interest in fishing, because he firmly believed, to quote the opinion of old Isaac Walton, that if you find people fishing you generally find honest men. He was glad to say that one effect of the Fishery Acts was to show that a very large number of persons from Birmingham and other places in the manufacturing districts resorted to the Severn and adjoining rivers for fishing. Since the beginning of last month they had issued over 500 licenses for trout fishing, the greater number being sold, not to persons residing in the district, but to anglers from a distance. They fixed the license at the low price of 1s. so as not to make it restrictive, but with the idea that the pleasure of fishing should be open to all.

MISCELLANEOUS.

ESPARTO GRASS TRADE OF TUNIS.

The following detailed account of the manner in which the esparto grass is collected and shipped may not be without interest, especially since many inquiries have been addressed to Vice-Consul Dupuis on the subject. Although more goes to Great Britain from Susa, yet the quantities collected on the more southern coast and shipped at Sfax and Gerba are very considerable, and may eventually exceed those at Susa, on account of shortness of distances and conveyance by water, rather than by camels, which is always costly. It is brought during a few months of the year, loose in bundles, from a number of places to Sfax and Gerba in boats, averaging from two to twenty tons. A good deal comes from Shebbah, some 35 miles to the north, and not an inconsiderable quantity by land-transport from Agareb, 20 miles inland. From the hills of Hamamah also and Zluss large supplies have lately been sent. Much comes from Shirah, 50 miles south, during four months of the year. At two or three days' journey inland from Susa the grass grows over a large tract of country, as is the case at Gabes, a name pretty well known, and some 30 miles further south round the coast. Here, likewise, the Akariat flows into the sea, being one of the few rivers in the country which sends water to the sea all the year round. It irrigates a strip of land about half a mile in width on its left bank, extending many miles up its course, and a luxuriant vegetation appears in strong contrast with the bare plains around. The staple product is the date of the different qualities consumed in the country. The last mile of the channel of the river forms a tidal harbour, which admits of the passage of boats up to seven tons burden only. Yet considerable trouble is experienced by them in bringing down the grass when the sea is at all rough, on account of the bar formed by the accumulation of sand at the entrance. It sometimes also happens that navigation is altogether suspended from the choking up of the passage for the waters, and the sand has to be cleared away at considerable cost and labour. It is to be noted too that loaded boats can only pass freely up the river during the ten days at spring tides, and empty ones during five days at neap tides. The right bank of the river close to the sea is high and steep, and the bundles of grass have to be pitched over into the barges beneath. Sometimes, without any other contrivance than what can be supplied by the rigging and a few planks, bales are put on board.

Shipments are made from the port of Susa direct to England, but owing to the bad holding ground and the shallows, vessels loading lie twelve miles to the northward, where they find good anchorage some two miles from the shore. The bales of grass are first weighed near the river, and then put on board the lighters as described, during the ten days of spring tides. If, owing to the neap tides, the lighters cannot approach, bales are carried down half a mile over the sands, below the bar, where they are easily shipped if the water is at all smooth, and the wind from the land. Zarat, 25 miles further south, is another station from which supplies are drawn. Its small harbour is formed by the narrow estuary of a stream, which runs only after heavy rains. Green or Bugreen, about 80 miles from Sfax, is another place which furnishes large supplies. It is brought from a distance of half a day's journey at the nearest, to three or four at the farthest. It is to be understood that the supplies near the coast become soon exhausted, and only if prices offer well can they be sought for at a distance.

These are the principal stations where the grass is collected. At Shirah and Green there are no villages near the shipping places, and the agents have to camp out. At Zarat there is a small one, but some distance off, where there is a tepid spring which irrigates groves of palm and other trees. At the former two places only brackish water is to be had. Though at Gabes it is plentiful, yet it is all hard and brackish. Besides the mentioned places, there are those of minor importance, such as Bugarah, in the bay indenting the land opposite to the island of Gerba, and Zerzis, a port 30 miles from the Tripoli frontier, where good anchorage is to be found even for large vessels if it were opened to foreign trade. The following is the way in which the grass is collected:—Much is brought by the Arabs themselves to the markets. Money or goods are often paid or consigned in advance for grass, which is to be delivered at some indicated shore-station. Advances also are made for that which is yet to be pulled and got ready for transfer, when animals have to be hired to bring it to the coast. Buyers are sometimes sent out to an Arab encampment, which serves as a centre, and take with them money or goods (the latter generally), oil and cloth (last year, barley), which they barter for the grass, and then bring to the coast.

FRENCH INDUSTRY AND COMMERCE.—IRON AND HARDWARE.

Amongst the inquiries made by the delegates of the Chambers of Commerce into the state of French industry, Mr. Frederick Brittain contributes a report upon the manufacture of iron and hardware. Although commissioned to act specially as the representative of the Birmingham and Sheffield trades, it appeared essential to inquire into the iron manufacture, because iron supplies the raw material for the principal articles of hardware, and, so long as the present high duty upon it is maintained, there is little hope of any reduction in the duties upon its products. These considerations induced Mr. Brittain to visit some of the large ironworks. At Terrenoir, he was allowed to inspect the works, and received explanations from the director, respecting the admirable system upon which they are conducted. A schedule, it appears, is affixed to the door of each workshop every morning, giving the details of all the work done therein on the previous day. Each schedule contains the names of the puddlers, and of their first and second underhands, and states the number of heats worked off, the quantity of coal and pig given out, the maximum and minimum of iron required from the men, the actual production realised, and the wages earned by each man. If the weight of iron produced

exceeds the minimum required, the men are paid at a higher than the normal rate for the surplus; but, if it does not reach the minimum, the deficiency is deducted from their wages. The director introduced this system into Terrenoir in 1858, after having seen its excellent results at the great iron works at Creusot, of which he was the director from 1851 to 1858. He affirms that its effect was, at the latter place, to raise wages 50 or 60 per cent. without prolonging the day's work, and to increase, prodigiously, production without rendering necessary any augmentation of capital. The result of this second experiment was equally satisfactory. Among the men at Terrenoir there is little drunkenness, and it would be difficult to find a place where there is more intense application to work. The men work twelve hours a day, and earn wages varying from 2s. 6d. for labourers, to 7s., 8s., or as much as 12s. per day for puddlers. Nature has done little for Terrenoir, but the skill of its directors, and the sobriety of its workmen, have enabled it to maintain successfully a competition with more favoured rivals. Almost the whole of the ore smelted there comes from the South of Spain and from Algeria, and its carriage represents a very serious proportion of the total cost. The coal used is bad and dear, costing about 11s. per ton.

In the neighbourhood of St. Etienne, a large number of those articles are produced which form the staple trades of Birmingham and Sheffield, such as anvils, vices, fire-arms, nuts and bolts, files, tools, and building ironmongery. It is difficult to give an accurate account of the wages paid in each trade, but from numerous inquiries made in St. Etienne, and in the neighbourhood, it may be affirmed that wages vary from 2s. 10d. to 4s. per day of eleven hours. Although the number of hours of work per week is nominally 66, a considerable loss of time is occasioned by drunkenness, which is far more prevalent at St. Etienne than in other French towns. The manufacturers of the district assert that there is a complete absence of this vice in the large, well-organised establishments, where the workmen are under a kind of paternal discipline, the chief object of which is to promote the desire to acquire some real property.

The works of MM. Japy, of Beaucourt, Haut Rhin, deserve a special mention. They give employment to about 5,500 hands, and constitute, like the works at Creusot, a city by themselves. At this remarkable place are manufactured watches, clocks, nuts and bolts, wood screws, padlocks, pumps, tin-plate ware, locks, and many other articles of ironmongery.

There are in the east of France several large manufactories of edge-tools, files, and saws. It is difficult to establish an average of the wages earned there, as the men are principally paid by the piece. The best men sometimes earn 4s. 5d. per day of eleven hours, but the average is considerably less. Since the Treaty of Commerce these establishments have made great progress, and now many articles, such as plane-irons, chisels, and gouges, are made there by machinery, while they are universally made by hand in Sheffield. It is only the sterling quality of Sheffield tools which enables them to compete with the more symmetrical and showy articles of the east of France, and it is certain that the Sheffield manufacturers will be compelled, sooner or later, to adopt machinery if they would save their trade from decay.

The principal seats of the cutlery trade are Chatelherault, Nogent, and Thiers. At the first-named place there is a large production of table-knives of good qualities. MM. Mermilliod Freres have adopted machines for forging blades, and each one is said to produce about 100 dozen per day. At Thiers, where knives of common quality for export are manufactured, there is only one small steam-engine, the motive power being supplied by a stream which flows down a romantic gorge. By the side of this stream, and over it, are built grinding wheels, and near the little rivulets which feed it may be seen workshops, which have been erected by cutlers, who have been tempted there by the convenient motive power. Thiers has an air of extreme penury, which may be attributed to the low wages paid to the men. The cutlers and forgers earn, upon an average, not more than 2s. to 2s. 2½d. per day of twelve and a half or thirteen hours. The grinders are better paid, their wages sometimes exceeding 4s. to 4s. 5d. per day. They attribute their privilege partly to the intermittent supply of water, as, after a drought, their employers are accessible to a strike. Some time ago it was proposed to form a reservoir for the purpose of supplying a constant stream of water, but the grinders opposed the scheme. Notwithstanding the poverty of the workmen of Thiers, there is considerable drunkenness amongst them, grinders being the chief offenders.

It is difficult, Mr. Brittain observes, to make an approximate estimate of the relative remuneration of English and French workmen, or of their hours of work; but, speaking generally, it may be safely affirmed that, in the iron and hardware trades, in the least favourable cases, English workmen earn 20 per cent. more in nine hours than French workmen do in eleven, twelve, or even thirteen hours, and that in a large number of cases the difference reaches 50 per cent. In many of the branches of the Sheffield trade the men earn fully twice as much in their short day as Frenchmen engaged in kindred trades can earn in their long day. The cost of living is not quite so high generally in France as in England. The workmen usually live upon very frugal fare, and in some towns seldom eat meat. The margin between the expenditure absolutely necessary to maintain a workman in good health, and the amount he receives in wages, is very much larger in England than in France. An English workman who submitted to the hardships endured by the French would be able to save four times as much out of his earnings as the latter. The secret of the wonderful prosperity and wealth of France is to be found chiefly in the sobriety, frugality, and untiring industry of its artisans and agricultural labourers, who usually succeed in saving something out of their very small wages.

SYDNEY INTERNATIONAL EXHIBITION, 1879.

The proposal to hold an International Exhibition in Australia originated with the Agricultural Society of New South Wales, whose annual exhibitions have for many years been conducted with success.

In February, 1878, the Government of the colony lent its sanction to the programme of the Agricultural Society, and caused it to be published in the *Gazette*. The Imperial authorities also gave their countenance, and communicated to Foreign Governments that an International Exhibition would be held in Sydney in August, 1879.

Meanwhile, the attention of the exhibitors of all nations assembled at Paris was drawn to the project by the N. S. Wales Commission there, of which Mr. Jules Joubert was secretary, which gave it wide publicity, and acted with a committee in London, of which Sir Daniel Cooper was chairman, and Mr. Edmund Johnson honorary secretary, in receiving applications for space from Great Britain and other European countries, and in furnishing all necessary information.

The growing magnitude the Exhibition assumed, and the deep interest evinced in the undertaking at home and abroad, made it evident that it had developed into a work of national importance, altogether beyond the powers and resources of the Agricultural Society; therefore, in November, 1878, the Government accepted the responsibility of carrying it out.

A site worthy of the occasion has been chosen in the

Domain, and spacious buildings are being erected by the Government.

The Parliament has voted a liberal grant in support of the undertaking, and the Commission appeals to the people of New South Wales, so to represent the natural wealth, the abundant products, and the magnificent resources of this colony, that, while doing justice to themselves on their own soil, they may fitly honour the guests who will come from all parts of the world to participate in the first International Exhibition ever held in Australasia.

If this colony should do its part worthily, the Commission hopes, with the co-operation of foreign nations, the mother country, and the other colonies, to carry the Exhibition to a successful issue.

The Exhibition will be opened the first week in September, 1879, and will remain open for six months.

The President of the Commission is his Excellency the Governor; the Executive Commissioner, Mr. Patrick Alfred Jennings. The President of the London Commission is the Earl of Belmore, K.C.M.G.; the Vice-President, Sir Daniel Cooper, Bart.; and the Secretary, Mr. F. Fladgate. The London offices of the Exhibition are at 5, Westminster-chambers.

For this Exhibition, as well as that at Melbourne in 1880, a Royal Commission has also been appointed, H.R.H. the Prince of Wales being the President.

CORRESPONDENCE.

AFRICA: A PARAMOUNT NECESSITY FOR THE FUTURE PROSPERITY OF THE LEADING INDUSTRIES OF ENGLAND.

I listened to Mr. Bradshaw's paper on the opening up of Eastern Africa with great interest, and would liked to have said a few words had time permitted.

The sad state in which trade now is, and the quantity of goods at present in stock which cannot be "placed," lead manufacturers, like Alexander, to look for new worlds to conquer. Africa is pointed to as one of these new worlds, and in my opinion most justly so. I may be permitted at the outset to quote from a paper I had the honour of reading before the Society of Arts in 1872, in which the following words occur:—"Many new lands are looked upon in the same light in which the whole of Africa was formerly, as

"'Barren sand,
Where nought can grow, because it raineth not;
And where no rain can fall to bless the land,
Because nought grows there."

But a mere glance at the 'Flora of Tropical Africa,' now publishing, reveals such floral riches as to require no prophetic foresight to predict a great commercial future." I have never had cause to alter my opinion with regard to Africa, and at the time of writing the above paper, I was, I may say, in daily communication with the late Dr. Welwitsch, who explored the Portuguese possessions on the West Coast. In looking over with him the plants he had collected, I could not help being struck with the vast vegetable wealth available to commercial enterprise. Unfortunately, travellers and others, from various other matters taking up their attention, or from want of appreciation of the importance of the subject, rarely bring home any information as to what commercial products there are which would be likely to meet with a market here. After all is said and done, commerce is the great civiliser, and if going hand in hand with well directed missionary effort, produces the greatest possible good.

As trade amongst such tribes as are to be found in Africa, must necessarily be conducted on the barter principle, it becomes of the highest importance that information be obtained as to what we can get in return, as it is of no use sending thousands of bales or cases of Manchester or other goods if one does not clearly see what the exchange will be. For this purpose inquiries should be instituted as to what products exist, and data collected on the spot as to the qualities obtainable, available carriage and labour, freight charges, &c., and the price the substance can be laid down in the London market.

In conducting these researches great care is needed, as a product may be very good, but not obtainable in sufficient quantities, the price may be too high, there may be no present demand, or it may not be able to supplant a well recognised and used product, although in some cases such new products, all other things being equal, may be able to supplement the supply. To test these various questions, about a hundredweight of any such substance should be sent, together with all necessary information.

It would be well if instructions, either general—or special, to suit particular countries—were distributed amongst consuls and residents abroad, and the resulting answers tabulated and arranged, so that some reliable information may be available on occasions such as the present one. If the Society of Arts could institute such inquiries much good would doubtless accrue. I append herewith a short series of instructions and desiderata, which may prove useful. To those who may wish for further information on the subject of this letter, I beg to refer to the paper already mentioned (*Journal of the Society of Arts*, vol. xx. p. 237, February 16th, 1872), and also to a paper on "The Connection between Economic Botany and Geographical Research," in the *Geographical Review* (June, 1873). I append a specimen set of questions.

Jas. Collins, F.B.S. Edin.,
Late Government Economic Botanist,
Straits Settlements.

Specimens and Information desired on Commercial Products, &c.

I.—*Vegetable Products.*

A.—Specimens and information on vegetable products used as—

a. Food, such as grains, esculent vegetables, starches, edible fruits, saccharine substances, &c.

b. Medicinal substances used for their real or fancied effects, charms, ordeals, and customs connected therewith.

c. Textile and paper materials, how prepared, with articles manufactured therefrom; whether bulky or not, and if means exist for preliminary preparation.

d. Dyeing and tanning materials, how prepared and used, with articles so treated.

e. Waxes, fats, fixed and essential oils.

f. Gums, gum-resins, oleo-resins, balsams, &c.; caoutchouc, gutta-percha; in the case of these the following—

1. Sample of crude juice, without any preparation whatever, care being taken to place the same, immediately on collection, in air-tight vessels, in order to guard against any spontaneous change taking place. If two such specimens can be sent, to one should be added a small quantity of liquor ammoniæ. Care should be taken to exclude light. Strong tinned cans would be convenient vessels to send the milk.

2. Samples of gutta-percha or of caoutchouc, prepared in as many different ways as possible, such as with the aid of (*a*) artificial heat; (*b*) hot water; (*c*) natural heat; (*d*) alum; (*e*) liquor ammoniæ; (*f*) acetic acid?; (*g*) any plant, and also sending a small quantity of the plant so used; (*h*) fresh water; (*i*) salt water; (*j*) burning sulphur, taking care to note the time occupied, and all the steps of each process, using in every experiment an uniform quantity of the same milk.

3. Samples of the whey-like substance which separates from the caoutchouc and gutta-percha during its coalescence.

4. Samples of prepared caoutchouc and gutta-percha in the form or forms proposed to export it in, care being taken that it is as clean and dry as possible.

5. Information on the average yield of each kind of tree, and at different seasons, the best season for collecting, and the relative yield by simple tapping; (*b*) tapping, assisted by binding, and total destruction. Of course, in practice, the two latter methods should not be resorted to. A specimen of the stem showing methods of tapping would be interesting.

g. Woods likely to be useful in ship-building, for railway sleepers, in house construction, for cabinet work and engraving, showing them by a horizontal section with bark attached, about six inches thick or less; a slab from the centre, and also from the sap, and two or three billets $2\frac{1}{2}$ inches square, 2-3 feet long from sound wood, so as to show figure, grain, lustre, colour, &c. They should not be varnished or polished. Information as to whether quick or slow growers, size, natural age, liability to insect attacks. The roots and boles are often useful for ornamental work.

h. Substances used for perfumes and incense, for miscellaneous purposes and customs connected therewith.

B.—Botanical specimens, as—

(*a*.) Dried specimens of a branch of the tree, having the leaves, flowers, and fruit attached (loose flowers should be secured to prevent mixing), and fruits if liable to split open to be secured with string or wire to prevent shedding of seeds. The plants may easily be dried between sheets of any porous paper, care being taken to change the paper a few times at first, till the plants are perfectly dry. The specimens should be as characteristic as possible; leaves on different parts of a tree vary in some instances very considerably. Also section of the stem with the bark on.

(*b*.) Specimens of leaves, flowers, and fruits, attached, preserved in a jar or bottle, in some spirit, as brandy, spirits of wine, or in acetic acid, or a solution of salt, care being taken that the mouth of the vessel be well secured to prevent leakage.

(*c*.) All the botanical specimens and the products should be gathered from the same identical tree.

(*d*.) When there is more than one kind of variety of tree yielding the same substance, complete specimens of each kind should be collected and sent.

C.—Information as to—

(*a*.) Vernacular names, whether generic or specific, whether the same name or different names are applied to the tree and its products; whether applied to other trees; their meanings and derivations, whether pure vernacular, a corruption, an introduced or commercial name.

(*b*.) Early navigation, trade routes, commerce, locality where produced; how products are obtained and prepared; if the products of different species are mixed or not, the quantities suppliable; number and distribution of the trees, effect of collection on life of plant; price, means of transport, and data on which any such opinions are based.

D.—Climatic conditions under which the plant grow best as—

(*a*.) Meteorological observations as to heat, humidity, elevation, &c.,

(*b*.) Soil in which each tree grows; whether they grow in exposed or sheltered spots; solitary or in clumps; on the skirts or in the depths of forests; by river banks or Savanahs, &c.,

Parcels of seeds, or live plants or cuttings should always be sent if obtainable, as such a collection of live plants would be highly interesting and valuable.

II.—Animal Products.

Used as or for—

A.—Food,
B.—Saccharine substances, as honey,
C.—Furs,
D.—Perfumes,
E.—Fats and oils,
F.—Skins, parchments, leather, &c.,
G.—Hair, bristles and feathers,
H.—Horn, ivory, bones, &c.,
I.—Dyes and pigments,
K.—Silk,
L.—Shells,
M.—Corals, sponge, &c.,

Also specimens, alive or preserved, of the animals giving these various substances.

III.—Mineral Products.

Such as gold, silver, copper, lead, tin, iron, and other minerals and rocks obtainable; sections of mines and strata, specimens of soils, &c., and any other geological information.

IV.—Machinery Manufactures.

Illustrations or models of—

A.—Native agricultural and mechanical tools and implements,

B.—Textile manufactures as cotton, silk, &c.

C.—Wood work as turning, cabinet work, ship-building,

D.—Stone work,

E.—Rope and basket making, coopering, dyeing, painting, &c.,

F.—Paper-making, printing, book-binding, &c.,

V.—Ethnology, &c.,

Illustrations or models of—

A.—Clothing, dwellings, weapons, domestic utensils, &c., skulls, &c., illustrated by drawings or photographs if possible. Also information on manners, customs, religion, &c.

B.—Antiquities. Such as old buildings, temples, remains, &c.

VI.—*General Natural History Collections, such as Insects, Birds, Shells, &c.*

All information given on personal knowledge should be distinguished from that given on the testimony of others.

Great care should be taken that the labels should be correctly and securely affixed to the specimens, and that the letter or other account should coincide with the numbers or names on the specimens.

For mineralogical specimens small canvas bags are better than paper, and, if packed lightly with paper or grass, will travel well.

Vegetable or animal substances should have camphor packed with them, as a preservative from insects.

Vegetable substances can be preserved wet in strong brine or spirit.

Small animals can be preserved in spirits, larger ones can be skinned and the skins rubbed over with arsenic paste or corrosive sublimate, alum, pepper, &c., but plain white arsenic is by far the best.

Jas. Collins.

THE CULTIVATION AND CROPPING OF BAMBOO.

Dr. King's letter, in your issue of the 18th, is a portion only of one he addressed the 6th February last to the Calcutta *Englishman*, I therefore confine myself to requesting you to insert that portion only of my letter replying to his in the same journal, as it is hardly worth while occupying your valuable space to carry on a controversy which, so far as I can see, can tend to no practical issue, as I most certainly am not desirous that Dr. King (with his expressed views) should be induced to make any further experiments with cropping bamboo.

Dr. King, however, does admit "that young bamboo shoots may, one day, become an article of export from India." This event has occurred somewhat sooner, perhaps, than the doctor anticipated, as I have this week

received my first consignment of "young stems" from Burma, which bear evidence of having been floated (which Dr. King asserts they will not do), the mud contracted in that operation still adhering to them; this I must remove ere I can make them into paper, which I propose doing next week; some of these shoots are over 20 feet in length, and 12 inches in circumference, and as regards quality, all I could desire.

On the rafts arriving at Rangoon, the stems were crushed by the rolls I sent out for Government. I must remark, however, that, due to their extreme lightness and bulk (they have cost me 40s. per ton carriage from Liverpool alone), it is clear that the export of raw bamboos from India can never develop into a trade; they must be converted into "stock" where grown or produced. Thos. Routledge.

Claxheugh, Sunderland, 23rd April, 1879.

[Copy.]

To the Editor of the "Englishman."

Sir,—Referring to Dr. King's letter in your journal of the 6th February, as I understand the question at issue between him and myself, it is as follows:—

In February, 1876, experimental plantations were ordered to be established by the Government of India, for the purpose of testing the cultivation and cropping of bamboo, and in a "memorandum" then officially issued by "Dr. Brandis, the Inspector-General of Forests," he directed attention to the main points to be determined thereby. Among other suggestions in this "memorandum," Dr. Brandis clearly pointed out "that the experiments undertaken should be as much as possible comparative; of a number of clumps of the same age, and species, and growing under the same conditions, some should be thinned lightly, others heavily, and the third group should be cut completely, leaving only a few old stems on the ground."

Now, what was the course pursued by Dr. King? Did he adopt any one of these three most practical and common-sense suggestions? By no means; but, on the contrary, he confined his experiments to "one single, faulty system," which he termed "Utopian," *i.e.*, chimerical, adding, "nobody can have a poorer opinion of the merits of the system which was followed in this experiment than I myself have."

To justify his failure (which I, very naturally, I think, criticised), he now wishes to "father" this system on me, and to substantiate this, quotes ingeniously, but not ingenuously, from my pamphlet; I say "not ingenuously," as although professing to quote textually (from page 7) six consecutive paragraphs, he has left out one, and that the most important one, the back-bone indeed of what he is pleased to call "my system;" the play of "Hamlet," in fact, with thepart of *Hamlet* left out, viz., the paragraph following. "in a similar manner to osier beds in England;" this Dr. King represents by * * * * my words being, "I have mentioned the latter as in order to stimulate a rapid, aqueous, and sappy growth, as also to provide for the dry seasons common to hot countries, a system of irrigation would be necessary, such a system indeed being at present practised with the sugar-cane in Egypt, Spain, and elsewhere."

Long before my pamphlet was published, however, in January, 1875, I addressed Dr. King, requesting his advice and opinion on bamboo cultivation and cropping, giving my views *in extenso*, and stating that I considered irrigation an essential, quoting rye-grass under irrigation in this country in illustration, but to this letter I received no reply till June. In July, having then learnt that experiments would be instituted to investigate the bamboo industry I proposed, I addressed another lengthy letter to Dr. King, suggesting that various systems of cultivation and cropping should be tested, sending him an account of the manner in which the bamboo, when cultivated for paper, was treated by the Chinese, from which I extract as follows:—

"To cause it (the bamboo) to produce an abundant crop for many years, the sprouts must be cut some distance from the ground; if they are cut on a level with the earth, the plant would be entirely ruined, perhaps because the shoots, being entirely stripped, would no longer be preserved from the burning rays of the sun, or because the branches and the leaves which grow in abundance round the foot of the plant cannot receive nourishment any longer from the air, and have therefore none to furnish the roots."

Dr. King did not acknowledge this letter, neither did he favour me with any further communication, but as he had ample time to consider the subject before he instituted the experiments ordered by Government, which were not commenced before June, 1876, it is very difficult to understand his system of procedure, and still more so his reasons for confining himself to "the one single system," which he condemned as "Utopian," as also why, with that conviction, he should not simultaneously have tested at least one, if not more of the three alternative or comparative systems recommended by Dr. Brandis, even if he disdained to test the system pursued by "the poor Heathen Chinee;" this, however, it lies with him to explain.

Thomas Routledge.

Claxheugh, Sunderland, 6th March, 1879.

DEPRESSION IN TRADE.

Mr. Cobb, in his reply to the discussion on his paper, says that foreign export bounties on sugar, though injurious to British refiners and colonial producers, benefit the general community. This is a point which has been denied, and, I venture to think, conclusively disproved. The sale of bounty-fed sugar below cost price must decrease the supply from unsubsidised sources of production; so that the consumer, who is now enjoying the temporary benefit of artificially low prices, will, eventually, be dependent on an artificial —and, therefore, unstable—supply, instead of one which would have been natural, reliable, and permanent. By accepting the temporary benefit of the bounty, he is, therefore, laying up in store for himself a certain prospect of scarcity and high prices.

George Martineau.

21, Mincing-lane, 9th April, 1879.

NOTICES.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

April 30.—Renewed Discussion on Mr. John Hollway's paper (read February 12) on "A New Process in Metallurgy." Prof. H. E. Roscoe, F.R.S., will preside.

May 7.—"The Government Patent Bill." By W. Lloyd Wise, Esq., Assoc. Inst. C.E. F. J. Bramwell, Esq., F.R.S., will preside.

May 14.—"The Automatic Hydraulic Brake." By E. D. Barker, Esq. Capt. Douglas Galton, C.B., LL.D., F.R.S., will preside.

May 21.—"Edison's New Telephone." By Conrad W. Cooke, Esq. Prof. J. Tyndall, LL.D., F.R.S., will preside.

African Section.

Tuesday Evenings, at Eight o'clock.

April 29.—1. "Light Railways for Opening-up a Trade with Central Africa," by John B. Fell, Esq.; and, 2. "The Advantage of Railway Communication in Africa, as compared with any other Mode of Transport," by J. Conyers Morrell, Esq. Captain Sir Henry Tyler will preside.

May 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society.

Chemical Section.

Thursday Evenings, at Eight o'clock.

May 8.—"The History of Alizarine and Allied Colouring Matters, and their production from Coal Tar." By W. H. Perkin, Esq., F.R.S.

May 15.—Continuation of Mr. Perkin's paper.

Indian Section.

Friday Evenings, at Eight o'clock.

May 2.—"The Wild Silks of India, especially Tussah." By Thomas Wardle, Esq. Sir P. Cunliffe Owen, C.B., K.C.M.G., will preside.

May 23.—"The Harbour of Kurachee." By W. J. Price, Esq., M.I.C.E. Sir William Merewether, C.B., K.C.S.I., will preside.

Cantor Lectures.

Third Course: Five Lectures by W. H. Preece, Esq., on "Recent Advances in Telegraphy."

Lecture II.—April 28.

The transference of electricity. Wires. Insulators. Supports. Gutta-percha, india-rubber. Underground wires and cables.

Lecture III.—May 5.

Simple telegraphy. Visual and aural signals. Telephones. Telegraphic writing.

Lecture IV.—May 12.

Duplex, quadruplex, multiplex, and harmonic telegraphy.

Lecture V.—May 19.

Automatic and fast-speed telegraphy.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

In the report of the discussion on Mr. Stoffel's paper, which appeared in the last number of the *Journal*, Mr. Frederick Braby's name was misprinted as Mr. Raper.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. W. H. Preece, "Recent Advances in Telegraphy." (Lecture II.)
Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. Dr. W. Allen Sturge, "The Disposal of the Sewage of Paris, with especial reference to the Sewage Farms of Gennevilliers."
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m., Rev. J. McCarthy, "Across China from Chin-Kiang to Bhamo."
Institute of Actuaries, The Quadrangle, King's College, W.C., 7 p.m. Mr. Cornelius Walford, "A Suggestion towards Adding a new Feature of Usefulness to the Institute of Actuaries of Great Britain and Ireland."
Medical, 11, Chandos-street, W., 8.30 p.m.
Law Amendment Society, 1, Adam-street, Adelphi, W.C., 8 p.m. Mr. Joseph Brown, "The Bills before Parliament for Extending the Liability of Public Companies and other Employers, for Injuries to their Servants, arising from Accidents, viz.:—1. The Attorney-General's Bill. 2. Mr. Macdonald's Bill. 3. Earl de la Warr's Bill. 4. Mr. Thomas Brassey's Bill."

Tues....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (African Section.) Mr. John B. Fell, "Light Railways for Opening-up a Trade with Central Africa." 2. Mr. J. Conyers Morrell, "The Advantage of Railway Communication in Africa, as Compared with any other Mode of Transport."
Royal Institution, Albemarle-street, W., 3 p.m. Mr. Ernst Pauer, "Schubert, Mendelssohn, and Schumann." (Lecture II.)
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. 1. Mr. G. F. Deacon, "The Paving of Street Carriageways." 2. Mr. O. H. Howarth, "Wood as a Paving Material under Heavy Traffic."
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Colonel Henry Yule, "Notes on Analogies of Manners between the Indo-Chinese Races, and the Races of the Indian Archipelago." 2. Rev. James Sibree, jun., "Relationships, and the Names used for them, among the Peoples of Madagascar, chiefly the Hovas; together with Observations upon Marriage Customs and Morals among the Malagasy."
Zoological, 11, Hanover-square, W., 8½ p.m.

Wed....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Renewed Discussion on Mr. John Hollway's Paper (read February 12) on "A New Process in Metallurgy."
Geological, Burlington-house, W., 8 p.m. 1. Mr. J. Arthur Phillips, "A Contribution to the History of Mineral Veins." 2. Mr. J. W. Hulke, *Vectisaurus valdensis*, a New Wealden Dinosaur." 3. Mr. Norman Taylor, "The Cudgegong Diamond Field, New South Wales." Communicated by Mr. R. Etheridge, jun. 4. Mr. R. Etheridge, jun., "The Occurrence of the Genus *Dithyrocaris* in the Lower Carboniferous, or Calciferous Sandstone Series of Scotland; and that of a Second Species of *Anthrapalamon* in these Beds."
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Annual Meeting.

Thurs...Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W., 8 p.m. 1. Dr. Maxwell Masters, "Note on the Occurrence of a Restaceous Plant in Cochin China." 2. Dr. J. Murie, "On the Structure of the Pouched Rats of the Genus *Heteromys*." 3. Mr. Thos. Meehan, "Nutrition in its Relation to the Fertilisation of Flowers."
Chemical, Burlington-house, W., 8 p.m. 1. Dr. W. Ramsay, "The Volumes of Liquids at their Boiling Points obtainable from Unit Volumes of Gases." 2. Mr. T. Pattinson, "A Method of Precipitating Manganese entirely as Dioxide, and its Application to the Volumetric Determination of Manganese." 3. Mr. R. Warrington, "The Determination of Nitric Acid as Nitric Oxide, by means of its Action on Mercury."
South London Photographic (at the House of the Society of Arts), 8 p.m.
Royal Institution, Albemarle-street, W., 2 p.m. Annual Meeting.
Royal Society Club, Willis'-rooms, St. James's, S.W., 6 p.m.

Fri......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. Thomas Wardle, "The Wild Silks of India, Especially Tussah."
Royal United Service Institution, Whitehall-yard, 3 p.m. Lieut.-Col. T. Bland Strange, "The Military Aspect of Canada."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m., Prof. John G. M'Kendrick, "The Physiological Action of Anæsthetics."
Geologists' Association, University College, W.C., 8 p.m.
Philological, University College, W.C., 8 p.m. Mr. A. J. Ellis, "Report on Dialectal Investigations."
Archæological Institution, 16, New Burlington-street, W., 4 p.m.

Sat.....Royal Institution, Albemarle-street, W., 3 p.m. Mr. H. H. Statham, "The Leading Styles of Architecture Historically and Æsthetically Considered." (Lecture II.)

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,380. VOL. XXVII.

FRIDAY, MAY 2, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

TECHNOLOGICAL EXAMINATIONS.

The Council of the Society of Arts, having received an application from the City and Guilds of London Institute for the Advancement of Technical Education, offering to take charge of the Technological Examinations established by the Society in 1873, and carried on up to the present time, have resolved to transfer these examinations to the charge of the Institute. The Council have also ascertained that the Science and Art Department will assist the City Institute in conducting the examinations, in the same way as it has hitherto assisted the Society of Arts. The Technological Examinations for the present year will, therefore, be carried on under the direction of the Institute, and all communications on the subject should be addressed to the Hon. Secretaries, City and Guilds of London Institute, Mercers'-hall, E.C.

CANTOR LECTURES.

The opening Lecture of the Third Course of Cantor Lectures, by Mr. W. H. Preece, on "Recent Advances in Telegraphy," was delivered on Monday, the 21st ult. In the unavoidable absence of the Lecturer, this lecture was read by Mr. H. R. Kempe.

The Second Lecture was delivered on Monday last, the 28th ult., by Mr. Preece himself.

The Lectures will appear in the *Journal* during the summer vacation.

SANITARY COMMITTEE.

This Committee met on Wednesday, the 23rd ult. Present—Mr. Edwin Chadwick, C.B., Lord Alfred S. Churchill, Sir Henry Cole, K.C.B., Major-Gen. F. C. Cotton, C.S.I., R.E., Capt. Douglas Galton, C.B., F.R.S., Mr. A. Coghlan McHardy, and Dr. B. W. Richardson, M. A., F.R.S. Mr. Edwin Chadwick was elected Chairman of the Committee, and Dr. B. W. Richardson was elected Vice-Chairman. The following were added to the Committee:—The Right Hon. James Stansfeld, M.P., Prof. Fleeming Jenkin, F.R.S., and Mr. C. N. Cresswell. A letter was read from Prof. Fleeming Jenkin, giving some account of the action of the Edinburgh Sanitary Protection Association; and it was resolved that further inquiry should be made as to how far such a system was applicable to the Metropolis. It was also resolved that application be made to the local sanitary authorities of the parishes of St. Martin's and St. Margaret's, with the view of ascertaining the amount of information in the possession of those authorities as to the connections of the house drains with the sewers.

PRACTICAL EXAMINATIONS IN MUSIC.

Arrangements have been made for an Examination in London in June. Intending Candidates should communicate with the Secretary.

AFRICAN SECTION.

Tuesday, April 29th. Capt. Sir HENRY TYLER in the chair.

The paper first read was—

LIGHT RAILWAYS FOR OPENING UP A TRADE WITH CENTRAL AFRICA, AND FOR THE COLONIES.

By John B. Fell.

It is the opinion of some of the principal African travellers, and of other competent authorities, that railways must necessarily form part of any great scheme for opening up a trade with Central Africa.

At the discussion on Mr. Bradshaw's paper, however, that took place at a meeting of this Society last month, there were gentlemen present who recommended the use of the African elephant, tamed and trained for the purpose, as affording a means of transport better adapted than railways to the peculiar circumstances and character of this enterprise. If their view of the subject were a correct one, it would be useless to enter into a consideration of the subject of the construction of railways in Central Africa; but the weight of evidence appears to be opposed to such a conclusion, as will be shown by Mr. Morrell, in the paper he will read this evening.

For the object of the present discussion I may, therefore, assume that the trade now proposed to be opened with Africa is to be carried on upon so large a scale that no other method of transport than that of railways could possibly meet its requirements, or ensure its success.

By the aid of railways and inland steam navigation on the great lakes and rivers, we may gain access to a vast population, amounting, we are told, to as many as 100 millions of the inhabitants of the regions of equatorial Africa.

A large portion of that Continent, from the Indian Ocean to the Atlantic, lying chiefly between the Equator and the 20th degree of South Latitude, including an area of one million square miles, can be reached from the West Coast by the rivers Niger and Congo, from the East Coast by the Zambezi and Shiré and the Lake Nyassa, and by the con-

struction of a railway from the Coast of Zanzibar to the Lakes Victoria Nyanza and Tanganyika. Short lines of railway would also be required for passing the rapids which at present interrupt the navigation of the great rivers.

A trade has for a long period been carried on, to a limited extent, on the West Coast of Africa, and up the rivers Niger and Congo; and, within the last two years, a company of Glasgow merchants have established a line of steamers and trading stations on the Zambezi and Shiré rivers and the Lake Nyassa. But the opening up of a trade has never yet been attempted between England and the thickly populated regions of the Great Upper Lake districts of Central Africa.

It is to this vast and important country of the remote interior of the Dark Continent, that public attention has been recently more especially directed, and it is for gaining access to these distant regions that railways have been considered to be an absolute necessity.

There are no navigable rivers flowing from the lakes Victoria Nyanza and Tanganyika to the Indian Ocean, but a mountain range, rising to an elevation of from 5,000 to 18,000 feet, separates the watershed of the lakes district from that of the country, 300 to 400 miles in width, bordering on the sea.

As, therefore, the opening up of a trade with this portion of Central Africa is more dependent, than in other parts, on the possibility of railway communication being established between the sea coast and the great lakes, I propose to consider the subject of the construction of railways at first chiefly in reference to the countries which can be approached from the coast of Zanzibar, and are said to contain a population of about 30 millions of inhabitants.

Of the various routes that have been suggested, on which railway communication might be opened with Lake Victoria, the shortest is about 500 miles in length, from Mombasa on the coast, following the track of the native traders to the Eastern shores of the Lake. Another route is from Osi, on the mouth of the river Dana, the course of which it follows until the summit level of the mountain range has been passed. It then takes the line of the river Yagama to the North Eastern reach of the Lake, a distance of about 500 miles, whence it may be continued to Uganda, a further distance of 100 miles.

Should such an extension, at any future period, be found necessary, this railway might be carried forward to the Lake Albert Nyanza, 200 miles, and join the river Congo, at a further distance of about 400 miles, making a total length of 1,200 miles of railway, which, with 1,200 miles of navigation on the river Congo, would open up a through steam communication from ocean to ocean across the African continent.

A third line on which a railway could be made is from Bagamoyo, opposite to the Island of Zanzibar, along the route of the Arab caravans to Mpwapwa and Unyanyembe, or Msuri, to Kagehei on the south-east of the Lake Victoria, a distance of 600 miles. From Unyanyembe the railway might be continued to Ujiji on Lake Tanganyika by making an additional length or branch of 300 miles. Or, otherwise, the two lakes might be connected by a railway of 100 miles in length, from the northern extremity of one lake to a point on the western shore of the other.

Until an accurate survey of the country has been made, it would be impossible to form any judgment as to which route it would be the most desirable to adopt for a railway to the Lake Victoria.

The Osi and Dana line would possess the advantage of having its termini in the territories of two friendly monarchs, while the Bagamoyo and Kagahei route, though 100 miles longer, is the one best known, and on which there is probably the largest population.

From the foregoing considerations, it appears evident that, in order to open up such a trade as would be of any real and substantial benefit to the manufacturers of England, and to the people of Central Africa, a railway of not less than 500 miles in length must be made.

This railway, along with steamers on the lake and its affluents, would at once place us in communication with six millions of people, nearly one half of whom are subjects of the King Mtesa, who is friendly to us, and favourable to commerce and Christianity.

Now we come to the special subject of this paper, which is to consider how a railway of 500 miles in length can best be made through an uncivilised country, and at a cost that would render such an undertaking financially practicable.

According to the information given us by African travellers, the country itself is not of a very difficult character, but we know that even narrow gauge railways, made over easy ground, have cost from £6,000 to £9,000 per mile, in India, New Zealand, and the Cape Colonies. Then it will be necessary to take into account the peculiar difficulties that will be met with, and have to be overcome, in these wild tropical regions of Africa.

There is but little available labour in the country, and workmen may have, to a great extent, to be brought from Europe or from India. Supplies of food and water can scarcely be obtained on portions of the line, and some localities are so unhealthy that caravans cannot pass through them without much sickness and loss of life. There are no roads of any kind, nor any means for the transport of materials for the railway, except the most expensive one, by natives carrying loads of 60 or 70 lbs. each on their heads.

Consequently, the cost of making an ordinary narrow gauge railway from the Coast of Zanzibar to Lake Victoria would necessarily be greater than that of a railway of the same kind, and over similar ground in such countries as India, the Cape Colonies, and New Zealand; but, assuming the cost to be only the same, a capital of from three to four millions sterling would have to be provided for making the railway, in addition to what would be required for the steam boats and for trading capital.

It would be difficult, and might even be impossible, to obtain so large an amount of money for making the first railway into Central Africa; and, unless it can be made for a less sum, it is not likely to be made for some time to come, and the prospect of opening up a trade with Central Africa may have to be deferred for an indefinite period.

Such being the conditions under which a railway into Central Africa, if made at all, must be made, wheels were attached to the engine and wagons.

I will point out what appears to me the best way in which its various requirements, as regards economy, and the difficulties of labour and transport, can be met.

I should propose to make a railway of 3 feet, or 3 feet 6 inches gauge. I would dispense, to a great extent, with earthworks and masonry, and to substitute for them a light iron structure or viaduct, on all parts of the line where the cuttings and embankments would exceed 3 or 4 feet in depth.

Earthworks, and culverts, and small stream bridges, generally form the most expensive portions of a railway, where there is any considerable amount of these works to be executed, as must necessarily be the case upon a line following the course of a mountain pass, from the coast to a summit of 5,400 feet above the level of the sea, and then falling 1,600 feet, along another valley, to the shores of the Lake Victoria.

Whenever the railway can be laid on the surface, or be made with light cuttings and embankments, not exceeding a maximum of 3 or 4 feet in depth, no better or cheaper form of railway than this can be made, and I would recommend no change in the ordinary method of construction up to this point.

But as the earthworks increase in depth, the cost increases in a still greater ratio, until, at a depth of 30 feet, the cost of each foot in depth has increased to five times the cost of the first foot in depth of the cutting or embankment; and so it is with the cost of the culverts and small steam bridges, only in a still greater proportion, as at the same depth, the length and cost has increased eight times.

There is no remedy, that I am aware of, for this inherent expensiveness of earthworks and masonry, other than that of getting rid of them altogether, and of using, as I have suggested, some other kind of substructure in their place.

There is no novelty in this method of making railways economically, except that it is an extension of one that has long been adopted in ordinary railway construction, since it is the practice, when an embankment exceeds 30 or 40 feet in depth, to substitute for it a masonry, timber, or iron viaduct, because, at that height, a viaduct is found to be cheaper than earthworks.

Viaducts in ordinary railways are made with sufficient strength to carry engines of 30 to 40 tons weight, or from 10 to 15 tons upon an axle. If, however, smaller engines only are required, with a weight of 2 or 3 tons upon an axle, then the cost of an iron structure to carry the lesser weight is so much reduced, that it becomes cheaper than earthworks, and may be used as a substitute for them, in many cases, and especially in the one we have now under consideration, at depths of 3, 4, or 5 feet.

As the cost of such an iron structure as I am proposing to employ will depend, to a great extent, upon the strength required, and this again on the weight of the engine it will have to carry, and as that weight will depend on the work the engine will have to do, I may state that the estimates of the cost of the structure have been based on the condition that engines of 8 or 10 tons weight will be sufficient for working the traffic of this first Railway in Central Africa.

There is no doubt that the whole of the traffic, for some time to come, could be conveniently carried by trains running at less than half the speed, and of less than half the weight of the trains upon English Railways, consequently the engines need not be more than about a fourth of the size and weight of the engines used in England, which would be the weight I have named, and these engines would have a load of 2 tons or 2½ tons upon each of their four axles.

The cost of a railway made on an iron structure, of an average height of 10 feet above the ground, and of the strength required to carry engines of eight or ten tons weight, including permanent way, freight, carriage, and erecting, would be about £2,500 per mile.

The portion of the line laid on the surface and on earthworks of an average depth of 2 feet, and up to a maximum depth of 4 feet, could be made for £1,000 per mile, and assuming the railway to consist of equal proportions of each kind of work, which would give an average height or depth of 6 feet throughout the whole length of the line, the cost of the railway would be £1,750 per mile. To this must be added £750 per mile for stations, sidings, rolling stock, &c., and the total cost of the railway complete and equipped would be £2,500 per mile.

If, instead of using a single engine and tender, two small tank engines of 6 tons weight each were used, working back to back, as on the Giovi incline in Piedmont, the cost of the railway, with rolling stock, &c., might be reduced to £2,000 per mile.

The larger of these estimates, however, is a considerably less sum, probably not more than a third, of what an ordinary narrow gauge railway would cost, for such a country as it would have to pass through, in order to reach the interior of Central Africa.

As it may be considered desirable to furnish some sufficient evidence of the practicability of making a cheap and efficient railway upon the plan I have proposed, I will give a short description of the light iron viaduct to be used in place of earthworks, as the substructure of the railway, the general design of which is shown in the drawings exhibited. It is formed of pairs of wrought iron lattice girders, supported on iron lattice pillars, placed 15 or 18 feet apart, and upon the girders is laid the ordinary cross sleeper permanent way, the sleepers being firmly fastened, by means of bolts and clips, to the upper flanges of the girders, and laid over the intersection of the lattice bars. The pillars are sunk 12 or 18 inches in the ground, and rest on a framework of wood or iron. The strength of both the girders and pillars is sufficient to carry the weights indicated, without straining the iron beyond 4 or 5 tons per sectional square inch, and the carrying powers of the structure may be considerably increased by using steel instead of iron, which can be done without any material increase in the cost. Messrs. De Bergue and Co., who have works at Cardiff and Manchester, have made a series of experiments for testing the carrying powers of wrought iron lattice pillars; and calculating the strength of those shown in the drawings, from the results given by their trials, they are of opinion that these pillars would carry a load of about 60 tons before showing signs of crippling; and that from 15 to 18 tons may be reckoned as a safe working load, whereas they would really only have to carry from 7 to 10 tons.

During the last six months I also have made experiments with different forms of wood and iron structures, testing the girders with dead weights up to breaking strain, and with rolling loads of $2\frac{1}{2}$ tons per axle, the axles being placed 5 feet apart. The result of the latter trials has been that the deflection of the 15 feet lattice girders, both wood and iron, has in no case exceeded one-fortieth part of an inch to the foot of span, which is allowed to be a very safe limit, and the deflection of some of the wooden girders has been only one-eightieth part of an inch per foot of span. I may remark here that, although wooden lattice girders are seldom used on railways, they seem to have some special advantages as regards strength and stiffness over iron, since by framing the lattice bars together, which cannot be so easily and cheaply done with iron, the strains are brought upon larger surfaces, and additional strength is given to what would otherwise be the weakest parts of the girders. Altogether, the results given by the trials of 12 different forms of timber supports and girders were very satisfactory, and, but for its less durability, it might be preferable to iron for the substructures of light railways.

In Central Africa, at elevations of 2,000 to 5,000 feet, in localities where timber of a suitable and durable quality can be obtained, and where there are no white ants, it might be used to some extent with advantage, for the purpose of greater economy, in place of iron.

A question of the first importance has now to be considered, as to the capacity of light railways, constructed on the method I have described, for carrying traffic. And the answer is, that their carrying capacity is exactly the same as that of ordinary railways worked by engines of the same power and weight. Up to the limits of its strength, the substructure of iron or timber is a perfect equivalent for the earthworks and masonry with which railways are generally made, and it will be seen that, from the surface of the substructure upwards, there is, in fact, no difference between these and ordinary railways, the cross-sleeper form of permanent way, points and crossings, level crossings, station arrangements, locomotives, and rolling stock being the same as those used on ordinary railways.

The method or system of construction, therefore, that I am proposing to adopt for the purpose of making cheap and efficient railways in Central Africa does not affect the working parts of the railway, but only those parts which are below what is called formation level, and I wish to call attention to this as a most important feature of the plan. In order to effect any material reduction in the cost of making railways, it becomes necessary to go to some extent out of the well beaten track of ordinary railway practice, and this must be done notwithstanding that some railway engineers may be inclined to disapprove of, and even to oppose such innovations.

But, at the same time, my conviction is that no greater departure ought to be made or tolerated from those methods of construction and working which have satisfactorily stood the test of long trial and experience, than what is absolutely necessary for obtaining the special object in view, which, in the case we have under consideration, is the most important one of greater economy in cost of construction, and such greater economy as would enable us to make light railways in a foreign country, where without it they could not be made at all.

The change I have recommended is not that of adopting a new type of railway, but only a new application of a form already in use. It is simply a change made in the relative proportions in which earthworks and viaducts exist in ordinary railways; in which there are a large quantity of earthworks and a short length of viaducts, whereas I propose to use a greater length of viaducts and a smaller quantity of earthworks. It will, therefore, be readily seen that it requires no further evidence beyond what is within the reach of everyone to prove that light railways, made in the manner I have described, will do the same work as other railways, in proportion to the size and power of the engines, and do that work as cheaply and as well as any other railway. It may, however, be useful to give a few examples of the working of railways that have been made upon the viaduct plan.

The first was a line of one mile in length, that was made seven years ago, from the Parkhouse iron mines to the Furness railway, in North Lancashire, and the gauge was only 8 inches.

The second was an experimental military field railway at the camp at Aldershot, also one mile in length, and the gauge was 18 inches.

The third was the St. Austell and Pentewan Railway, in Cornwall, about 4 miles in length, and the gauge was 2 feet 6 inches. The Parkhouse 8 inches guage miniature railway was in operation about $3\frac{1}{2}$ years, after which a full guage branch line was made up to the mines; it was worked by a stationary engine and endless wire rope, and carried 26,000 tons of iron ore, timber, and coal per annum. It carried over 300 tons per day when the mines produced that quantity, which is equal to a traffic of 100,000 tons per annum. The structure was made of Baltic red pine timber, and there was no expense whatever caused by repairs or maintenance during the three years. The cost of the railway, with sidings, engine, wagons, and stations was £2,000.

The Aldershot Railway was made to fulfil certain conditions, considered by the War Department to be necessary requirements of a military field railway, and these were that, over an undulating country, it could be made by 500 men at the rate of one mile per day.

The wagons were to carry three tons each of dead weight, and an engine of $4\frac{1}{2}$ tons weight was to draw a load of 25 tons upon an incline of 1 in 50, and run at a speed of from 10 to 20 miles an hour.

These conditions were all fulfilled, and some of them were exceeded, as the engine took trains of 25 to 30 tons up a gradient of 1 in 50, and portions of the railway, when taken down, were put up again at the rate of two miles, in place of one mile per day, with the labour of 500 men. The cost of this railway, stock, and stations was £3,000, and I have received from the Secretary of State for War an official statement of the correctness of these facts, and that in the trials, which occupied a period of 18 months, all the above-named conditions had been satisfactorily fulfilled.

As a compensation for the extremely narrow guages of these two railways, horizontal guide

These were made to run upon guide rails fixed on each side of the structure, and by their aid wagons of more than three times the width of the guage could safely be used. But in practice they were found to be attended with certain inconveniences, inasmuch as there could not be any level crossings upon the line, and it became necessary to continue the structure throughout, so that, when the railway was on the surface, that portion of it became more, and not less, expensive than the ordinary cross-sleeper road. For these reasons, on the St. Austell and Pentewan Railway, I decided to increase the gauge to two feet six inches, and to give up the horizontal guide wheels. This railway was opened in 1873, the engine is six tons weight, it draws a train of 50 to 60 tons up 1 in 100, and has carried a traffic of 20,000 tons of china clay, coals, and merchandise per annum. The cost of this railway was £2,500 per mile, including rolling-stock and stations. On this latter railway 25 to 30 trains per day could be run in each direction, carrying 30 to 40 tons of goods in each train, which is equal to a traffic of 2,000 tons per day, and far in excess of the probable traffic of any one railway, for a long time to come, in Africa.

In reference to the Aldershot and Parkhouse railways, I have observed that there was this disadvantage, caused by the use of horizontal guide wheels, that it was necessary to continue the structure even when the line was on the surface, and where there were no works to be executed, and no expense to be saved. Upon these portions of the railway the viaduct system, with the guide wheels, consequently, became more costly than an ordinary narrow gauge railway, and thus partly neutralised the advantage derived from the use of it on the portions of the line when it took the place of heavy earthworks.

The structure, when used without the guide wheels, is not only free from this inconvenience, but it has the advantage that it may be employed in combination with earthworks in any relative proportions; as, for example, in places where labour is cheap, and excavation easy, the earthworks might be carried up to a height of five or six, instead of three or four feet, or to any other height at which they could be made at the same cost.

When speaking of the expensiveness of heavy earthworks, I pointed out that, in a bank of 30 feet in depth, each foot in depth at the bottom of the embankment cost five times as much as a foot in depth at the top of it.

With an iron structure, however, exactly the reverse is the case, the cost of the lattice pillars per vertical foot being nearly equal throughout, while that of the girders, being distributed over the additional feet in height of a 30 feet structure, rapidly diminishes; so that, while the cost of earthworks per vertical foot, increases with each additional foot in depth, the cost per foot of the lattice girders and pillars combined, within certain limits, on the contrary, diminishes with each additional foot of height; hence the great advantage of using a light iron structure as a substitute for heavy earthworks, and indeed for any earthworks above a very few feet in depth.

I hope I have now been able to show satisfactorily, from both theory and practice, that a railway made of light earthworks, and a light iron structure combined, can be constructed over a somewhat difficult country at a small cost, and that such a railway would be capable of carrying all the traffic that is likely to be brought on to a railway made from any point on the coast into Central Africa.

There are one or two matters, however, materially affecting the cost of any such railway, of which I have not yet spoken, and these are the most important items of labour and the transport of materials.

The trials made by the War Department at Aldershot, of which Captain (now Major) Luard and I had charge, proved that a railway made on a succession of timber or iron viaducts could be constructed, so far as relates to the work to be done on the ground, at the rate of one mile per day, by the labour of 250 men. One-third of these were sappers, or skilled workmen, and the remainder men of the line, or labourers only; the latter being employed in carrying and lifting the materials, and making and filling up the holes for the supports. For the work in Africa we may estimate a force of 300 men would be required, of which 100 would be Europeans, and the other 200 natives, who, while they are of but little value with a pick and spade, are good for such labour as carrying and lifting to their places the parts of an iron structure, the sleepers, rails, &c.

There would be no difficulty in providing tent accommodation, food, water, and all needful supplies, for these 300 men, since what could not be obtained in the country might be easily sent up from the coast, with which they would be in constant communication by means of the railway. When working in unhealthy parts of the line, the men, or at any rate the Europeans, could be taken to some healthy locality, 10 or 20 miles off if need be, and brought back to their work in the morning,

The component parts of the structure, being so simple, so easily erected, and bolted together, there would be no difficulty in constructing a railway of this kind, with the materials prepared beforehand, by the labour of 300 men, at the rate of one mile per day, at which rate of progress, assuming there were no extraordinary works, such as the crossing of great rivers, to be executed, the 500 miles of railway might be completed within two years, or 600 working days, cases of *force majeur* excepted.

No land transport whatever would be required, since, as the railway advanced, it would bring up into the interior all its own materials from the point at which they were landed on the sea coast.

The portions of the line that were on the surface, or where the earthworks did not exceed an average of two feet in depth, could be made by the same number of men, and in the same time, as the other part of the line constructed with an iron viaduct.

If, however, instead of the iron structure, one half of the total length of the railway were made with earthworks and masonry, of an average depth of ten feet, as has been assumed in the estimate, and these works were commenced at intervals all along the line in the usual manner, or even upon any considerable sections of it, then, in an uncivilised country, without roads, means of transport, or suitable supplies of labour and food, difficulties of great magnitude would arise. The quantity of earthworks to be executed would be increased tenfold, as, with a width of formation of

nine feet, and slopes of 1½ to 1, the sectional area of a two feet bank is 24 feet, and that of a ten feet bank or cutting 240 feet.

In the latter there would be about 47,000 cube yards of earthwork per mile, and reckoning eight cube yards to be the work of one man per day, it would require a force of nearly 6,000 men to make one such mile of railway per day, in addition to whatever number might be required for the masonry in the culverts and small stream bridges up to 15 feet span, for which probably another 1,000 men would have to be provided, making a total of 7,000 in all, and allowing 300 men for the light portion of the line, an average number of from 3,000 to 4,000 men, in place of 300 men, would have to be employed during the whole period of the execution of the works.

These men would have, to a great extent, to be brought from other countries, and the difficulty, to say nothing of the cost of providing them with shelter and food, scattered as they would be over many miles of almost inaccessible country, may be more easily imagined than described.

In the comparative estimates given, I have assumed that a railway made entirely of earthworks would cost only three times as much as one made with light earthworks and a light iron viaduct combined; but taking into account not only the extra quantity of work, but the still greater difficulties under which that work would have to be executed, it is more than probable that the cost of the former would be five times that of the latter, and would also occupy a longer period, it might be five years instead of two years, in construction.

We shall now have to consider the question of the cost of transport by railway, from the coast of Zanzibar to the shores of the Lake Victoria, of which only an approximate estimate can be formed. The cost of carriage upon such a railway would depend much upon local circumstances, such as the gradients on which the trains would have to run, the cost of fuel and of enginemen's wages, the quantity of traffic to be carried, and the greater or less cost of maintenance.

For the first year or two, the traffic would, doubtless, be small; but, with the immense resources of the region of the lakes in Central Africa, it may not be unreasonable, at an early period, to count on a traffic of at least 100 tons (or passengers) per day, in each direction, the average rates of charge per passenger and per ton of goods being about the same. The two classes collectively would be equal to a total traffic of 60,000 tons per annum.

As regards locomotive expenses, wood found in the country could be used for fuel, and negroes are said to make good firemen; so that the only expensive items would be the wages of the engine-drivers and mechanics. The cost of maintenance would be very small—indeed, less than on ordinary railways—and much less than where heavy earthworks are used in the tropics.

The gradients of the railway, on the whole, appear to be favourable, and we are told it is the opinion of some of the African travellers that 1 in 40 is the steepest gradient that need be used. The average gradients are about 1 in 200 on the eastern side, and 1 in 300 on the western side, of the summit of the railway.

So far as an opinion can be formed on these general conditions, the working expenses of the railway probably need not exceed 1½d. per ton per mile; and if a rent-charge be made for the use of the line, or 10 per cent on the capital employed, there must be added to the working expenses the toll of 1d. per ton, making together a total average charge for the carriage of merchandise and produce of 2½d. per ton per mile.

The rates of carriage for the more valuable articles might be 4d. or 6d. per ton, and for those of less value 1½d. or 2d. per ton per mile. Of the traffic outwards for export a portion of the produce of the country, such as the inferior kinds of timber, would not bear the expense of carriage over the whole length of the line, but might be brought from distances of not exceeding 300 miles, on which they would travel principally on a falling gradient, on the eastern side of the summit. The more valuable kinds of timber and grain might be brought from the countries bordering on the lake, while supplies of such articles as ivory, spices, cattle, cotton, coffee, tobacco, and dye woods could be drawn from a great extent of country beyond the western terminus of the railway. The chief part, if not the whole, of the traffic inwards being manufactured goods, would bear the cost of carriage for the entire length of the line, and would probably find their way for a distance of 500 miles, or more, beyond it.

I will not make any remarks on the immensely superior advantages of travelling, and of the transport of goods by railway, for the purpose of opening up a trade with Central Africa, and especially as compared with all other available means of inland carriage, since this very important part of the subject before the meeting will be ably treated by Mr. Morrell this evening.

I think it right, however, before concluding this paper, to make some observations on a plan for making a railway into Central Africa that has been recommended by Mr. Haddan, and which has been called the Pioneer, or single rail system. I should not have thought it necessary to make any allusion to this subject, but for the circumstance that considerable publicity has been given to it; and that it has been brought forward apparently under the auspices of several eminent men, who, though not railway engineers, have been regarded as in some degree responsible for the statements which have been made relative to this particular form of railway.

Mr. Haddan has represented that a railway, consisting of one carrying and two guide rails, supported on a single row of posts, can be made over an undulating country, including rolling stock, for £1,000 per mile. Also that an engine of eight tons weight would draw a train of 100 tons up an incline of 1 in 10 on this railway, at a speed of eight miles an hour, which I may say, and I think without fear of contradiction, is a physical impossibility.

It is a matter of fact, and not of mere opinion, that the resistance due to gravity of a train of 100 tons ascending an incline of 1 in 10, is a tenth part of the weight of the train, or 22,400 lbs., and that the resistance from friction is equal to 10 lbs. per ton on the gross weight of the train, with 10 lbs. extra on that of the engine, being an additional 1,080 lbs., and 23,480 lbs. collectively.

The tractive force of the engine must be equal to

the sum of these resistances, and this force has to be developed at a speed of eight miles an hour, or 704 feet per minute. Everybody knows that the mechanical force in pounds multiplied by the speed in feet per minute, and divided by 33,000, gives the actual amount of horse power employed, which for this 100 ton train, so computed, is the power of 500 horses.

No locomotive engine of 8 tons weight has ever yet been made capable of developing anything like 500 horse power; and, in the present state of mechanical science, it is not possible to make one. When the time arrives for such an achievement, there will be little need of railways, as we shall have passed into the domain of the Aeronautical Society, who would not be long in making a successful flying machine, if furnished with an engine exerting 1-horse power to every 38lbs. of its weight, which is the proportion of the power to the weight of Mr. Haddan's proposed engine.

Mr. Haddan maintains that, because his engine derives its adhesion from the pressure of the side gripping wheels only, and not from its weight, that it can be made lighter than other engines to the extent he has assumed, which, however, is a fallacy; and he has either not taken account of the power required for drawing a train of the weight, at the speed, and up the gradient he proposes, or otherwise he has miscalculated the weight of the materials indispensable for constructing such an engine.

Along with Mr. Brunlees and some other gentlemen with whom we have been associated, I have had 15 years' experience of the working of engines with horizontal gripping wheels, and being quite independent of weight for adhesion, these engines were made with the utmost economy of weight, the boilers, frames, and the working parts being of steel, and yet it was not found possible to reduce the weight of the engines to less than about 200 lbs. per horse-power. I do not see any reason for believing that Mr. Haddan, who can scarcely have had the same amount of experience in the working of engines with horizontal wheels, if indeed he has had any such experience, will succeed in making more powerful engines in proportion to their weight than we have been able to make; and, in such case, the weight of the train his 8-ton engine would draw on a gradient of 1 in 10 at the speed of 8 miles an hour, would be 12 tons only, and not 100 tons, as he has represented. In consequence of the smallness of the load that can be carried, the cost of traction is so great on gradients of 1 in 10, that they ought never to be used except in crossing mountain ranges, for the purpose of avoiding gigantic tunnels and works; and whenever gradients of 1 in 50, or 1 in 100, can be obtained at a moderate cost, it would be folly to admit of gradients of 1 in 10, or even of 1 in 20.

Not only are the engines and gradients proposed by Mr. Haddan unsuitable for railways in Africa, and indeed for any other country, but the single rail form of railway is itself open to very serious objections. Resting on a carrying rail of only 4 inches in width, the engines and wagons, with the whole weight of the train, must have an overhang of 2 feet or more on either side of this rail, and an inconvenient oscillation of the train is caused by the slightest irregularity in the road.

This tendency to oscillate, I found in the trials I made of the single rail system some time ago, was materially increased by the pannier form of the wagons, which easily received and maintained a pendulum-like movement, causing a heavy pressure on the guide rails, and adding considerably to the frictional resistances of the train.

The single line of posts which support the railway have but little lateral strength or stability to oppose to this disturbing action of the trains, and it would be very difficult to maintain them in a vertical position. They would soon be found to be leaning to one side or the other, and when leaning in opposite directions, the single rail would make a most uncomfortably zigzag road to travel on. This system is also ill adapted for sharp curves, as either the beams must be bent, by which they lose much of their strength, or the railway must be made of a series of angles and straight lines. Instead of being more simple than an ordinary railway, it is really more complicated, since it has three rails instead of two, and the engines and carriages have three axles and three wheels where there need be only one axle and two wheels. Each wagon being divided into two compartments is a further disadvantage. The system admits of no level crossings, which is a very serious drawback, and the points and crossings are of an expensive and inconvenient kind.

Although I took out a patent for the single rail system ten years ago, and intended to use it, I was convinced by the trials I then made, that, on account of the defects and difficulties above named, it was much inferior to the ordinary system with two rails. I therefore abandoned it, and for the Parkhouse Mineral Railway adopted a narrow guage permanent way on a light timber structure, and I am satisfied it answered the purpose much better than a single rail line would have done.

I am unable to see what inducement there is to adopt so inconvenient and hazardous a novelty as a single rail, or kind of bicycle railway. There can be no doubt that Mr. Haddan is quite right in seeking for some cheap substitute for earthworks and masonry, but this can be done by using such a structure as I have already described, without departing from the ordinary and well-established types of engines, carriages, and permanent way. And the object in view, which is economy in the cost of construction, can be better accomplished by a two-rail than by a single rail structure, because, by employing the same quantity of material, the carrying powers will be the same in both cases, and the two-rail structure, by a better distribution of the materials, provides that lateral stability which is indispensable for a railway, and which the single rail structure does not possess.

If Mr. Haddan is of a contrary opinion, and is willing, like others, to assume the risk and trouble of putting his plans to the test of actual experiment, the question can soon be settled as to whether his great expectations can be realised or not. And until such evidence is forthcoming, I think the general opinion will be that the history and results of the trials of the single rail system of railway, since the time when Mr. Palmer took out the first patent for it, 50 years ago, all point to the improbability of its ever becoming a success.

After having appreciated, to an extent that perhaps few engineers have done, the necessity that

has arisen for making cheap railways, specially adapted for foreign countries, and having gone so far in the right direction as to have recognised the necessity of finding an economical substitute and equivalent for expensive earthworks, Mr. Haddan seems to me then rather to have missed his way, just as I did ten years ago, and very much in the same direction; but if he is now willing to profit by the experience which cost me both time and money, and give up his guide rails, and use two carrying rails in place of the single rail, he may then, by means of his energy and skill, do good service in the work of providing cheap railways for Central Africa.

If I might venture to make such a remark, railway engineers do not seem to be sufficiently alive to the signs or the requirements of the times, in respect of the great and urgent need that has arisen for a less expensive class of railways than any that now exist.

The Government of India appeared to be of this opinion when they took the construction of railways in that country out of the hands of civil engineers and English companies, and for the purpose of economy, assumed the construction of them themselves. Such also appears to be the opinion of the Secretary of State for the Colonies, from the few words of friendly reproach addressed to the profession which fell from him at the last annual dinner given by the Institution of Civil Engineers.

The too great cost of railways for new and comparatively poor countries, is probably one of the reasons why railway engineers in general have at present so little to do, and they might not be able to find a more profitable occupation for their time, than by practically working out in detail such improvements in the method of construction, as would have the effect of bringing railway communication within the reach of countries which cannot afford to pay the price that even narrow gauge railways have hitherto cost, in England and in the Colonies.

It appears to me that one of the great problems now waiting for solution in modern railway engineering is, how best to make a railway that shall have one-fourth or even a fifth part of the carrying powers of existing railways, for about one-fourth of the sum that the cheapest railways at present cost.

There will be difficulties to be overcome, but there is no doubt that the successful solution of this problem would open a world-wide field of enterprise for English engineers, to many of whom it would probably be as acceptable as an extension of trade would be at the present time to our merchants and manfacturers.

In conclusion, I will briefly recapitulate the suggestions I have had the honour of making to this meeting of the African Section of the Society of Arts, with a view to facilitate the construction of light and inexpensive railways for opening up a trade with Central Africa, and also for increasing the existing trade and resources of our African Colonies.

I would submit that it is an absolutely essential condition to the making of cheap railways in Africa, that heavy earthworks and masonry must be dispensed with, and that some less expensive equivalent, such as a light iron or timber structure, must be used as a substitute for earthworks where they exceed a very few feet in depth.

That, in any special method of construction employed, there should be as little variation or departure as possible from existing and well-established types of engines, carriages, and permanent way.

That the particular form of railway adopted, whatever that form may be, must include an arrangement by which a regular communication can be maintained between the point at which the works are being carried on and the sea coast, as a base of operations, in order to be entirely independent of the resources of the country for obtaining the necessary supplies of materials, food, and labour. And I further wish to call attention to the necessity, before any other steps are taken, of having a careful survey made over whatever route may be selected for the proposed railway, from the coast at Zanzibar to the Lake Victoria Nyanza, since engineering difficulties, and a large amount of expenditure, may often thus be avoided.

If these conditions are carried out, there is every reason to believe that light railways may be made in Central Africa at a cost, when the line is on the surface, of £1,000 to £1,500 per mile, and of from £2,000 to £2,500 per mile when works of an average depth of 10 feet are required for one-half of the length of the railway. And that when so made, these railways would be worked with as much certainty and economy as any other existing railways.

The second paper read was—

THE ADVANTAGE OF RAILWAY COMMUNICATION IN AFRICA, AS COMPARED WITH ANY OTHER MODE OF TRANSPORT.

By J. Conyers Morrell.

The opening up of Africa to trading operations, on a scale commensurate with its area, its natural wealth, and its population, is now becoming one of the prominent interests of the day. Those who have advocated the necessity of securing new or extended markets for British productions have pointed to this great Continent as the grand field which is to supply this necessity, and which is to become the great market of the future. The civilisation of a country possessing a population of over 200,000,000 is also a matter of no small concern to the philanthropist.

In discussing the best means of promoting this great work, I venture to assert that transport communication may be ranked as of the first importance.

Trading operations have been carried on for many years with Africa, but these have been of a very limited extent, and have been confined mainly to the coast line of this continent; by limited I mean in proportion to the area, natural wealth, and population of Africa. A considerable trade in palm-oil, shee-butter, ground nuts, &c., has been, and is now carried on, on the West Coast. But so far as I can make out, with the exception of the Niger country, this trade seems to have reached its limit, and when we inquire into the cause of this, we find it is mainly due to the absence of facilities for penetrating the country beyond a few miles from the coast.

Ages ago, an arm of the sea appears to have ex-

tended itself far into the interior of the great northern portion of the Continent, but this important water communication no longer exists, and the area it occupied, has become what is now known as the great Sahara, or sandy desert. It has been suggested by Mr. Donald Mackenzie, and for my own part I look with great favour upon the suggestion, to flood this desert, and re-produce, so to speak, an arm of the sea, and thus again secure a water communication. In considering the feasibility of this work, it must, however, be remembered that a considerable portion of country which would thus be thrown under water, is now occupied and cultivated, and also that the difficulty and expense of keeping the waterway open, owing to the drifting sand, might prove insurmountable. But there can be no doubt that if such a water communication could be established, and efficiently maintained at a reasonable expense, and without injury to existing property, it would prove a most valuable work, yet this; when accomplished, would leave a great and important portion of the continent still to be provided with a transport communication.

The development of England's wealth is undoubtedly due, in a great measure, to her water-carriage surroundings, and wherever water-communication is available it is found to be the best and cheapest mode of transport.

Africa, unlike the other great continents of the world, is singularly destitute of a water communication penetrating far into the interior, or rather, it should be said, of one available for commerce.

The Nile is an important river, and has, by some, been looked upon as the highway to the interior; but the recent declaration by Colonel Gordon of its utter impracticability for this purpose may be considered as final. He says, that "he is convinced that the commercial highway of Europe to the rich equatorial districts of Africa is not by the Nile, but from the East Coast upon the Indian Ocean. Navigation by the upper Nile is impossible, owing to rocky cataracts, to the vast marshes over which the river water is at places spread, and because of the abundant growth of weed by which the stream is sometimes choked."

The River Nile may, therefore, be considered as navigable only to the extent of about 800 miles, and valuable merely as a fertiliser of the land through which it flows, and which, it must be remembered, is a tract not exceeding about 15 miles in width along its course.

The next great river is the Niger, which flows south of the western part of the great Sahara, and has its outlet by many mouths into the sea on the west coast. This is without doubt the most important river in Africa, and has been navigated a distance of at least 600 miles from its mouth without a break, and, for that portion of the country which it serves, is a most valuable water communication; but a glance at the map of Africa will show that, instead of its course running directly into the interior, it has a tendency to approach at its rise another part of the westerly coast.

It will thus be seen that, though an important and increasing trade is done on this river, it does not supply the needed communication with the central regions of Africa. There are a number of smaller rivers on the West Coast, such as the Gambia and the Senegal, but only one or two of these have been found to be navigable for as much as 150 or 200 miles, and so, beyond serving for comparatively insignificant trading purposes, may be passed by.

The next great river is the Congo, or Livingstone, with its outlet also on the West Coast. This, at the first glance, would appear to offer the much-desired water communication with Central Africa. Its course has been traced by Livingstone and Stanley, and in parts it has been found to be as much as from three to five miles wide; but, unfortunately, when entered at its mouth, it is found to be navigable only for about 60 miles. At this distance inland, cataracts are met with, which extend for about 200 miles along its course; after these are passed it is again navigable for about 1,400 miles, when cataracts are again encountered, and so we cannot look upon this as an uninterrupted water communication to the interior of the country.

Leaving the West, and turning to the East Coast, we find only one river which can be said to be navigable for any distance; this is the Zambesi. This river has a clear course for about 400 miles before reaching cataracts. At a distance from its mouth of 100 miles the river Shiré falls into it, and this river (Shiré) is navigable for 200 miles, when the Livingstone rapids are met with, which extend along its course for about 50 miles. After passing these rapids the river is again navigable until it reaches Lake Nyassa. Though this may be looked upon as a very important water communication with that portion of the interior, the 50 miles of rapids reduces its value very much, and, on its own unsupported merits, it fails to supply the requisite inroad.

Efforts have been made to navigate a few of the smaller rivers on the East Coast, such as the Dana, the Osi, the Wami, the Kingani, and the Rovuma, but, so far, without that success which entitles any of these to be considered as of any value for commercial purposes.

We thus find ourselves forced to the conclusion that, whatever use can be made of the waterways referred to, they are far from affording that rapid and perfect transport communication, which is necessary for the speedy development of trading operations with the interior of the continent. Hence, we must look elsewhere to find the requisite means of communication for conducting trading operations with what Col. Gordon describes as "the rich equatorial regions of Africa." By the equatorial regions must be understood that part of Africa in particular which lies within 10° north latitude and 20° south latitude. That portion of the continent which lies north of these lines, and which comprises Egypt, Algeria, Morocco, a great part of the Niger country, and the Sahara, and that portion which lies south, and which comprises the Cape Colony, Orange Free States, the Transvaal, Zululand, and the Matabéle country, may, for the present, be left out of the question, as these are already more or less under the direction or influence of civilised peoples.

In discussing the question of transport, we shall also find ourselves the more able to arrive at a correct decision, by confining our consideration to the treatment of that part of the continent which, it is true, presents the most difficulties, but which,

at the same time, offers the greatest inducement, from its greater natural wealth and its very much greater proportionate population, to the skilful, enterprising, and legitimate trader.

The *Pall Mall Gazette* recently reminded us that the true fields which remain for the sale of British goods tend constantly to be the barbarous or half-civilised countries of the world. If we refer to the history of the past, we shall find this view confirmed, and that much of England's prosperity is due to her commercial intercourse with such countries. Where, therefore, can we find now, in this hour of our need, a field which answers this description more perfectly than the equatorial or central regions of Africa, for there, we are told, the population is at least one hundred millions, and that the products include corn, maize, tobacco, cotton, rice, millet, chilli, ginger, caster bean, cassawa, sugar cane, indigo, gums, especially copal gum, india-rubber, horns, hides, wax, besides ivory and other products, in exchange for which the people are, as we know, willing to take our cotton goods, woollen blankets, Birmingham and Sheffield ware, and other articles.

Thus we have a large population, occupying a rich country, requiring only that impetus to the encouragement of industry, and the development of the country's wealth, which is to be found alone in the application of the best known means of transport communication.

We have seen that water-carriage is not in itself available. I contend, therefore, that the only effective transport communication is to be found in an iron road, or, as we commonly understand it, a railway. But, when I speak of a railway, I do not mean such a one as is represented by any of the main lines in this country. I mean a railway of that light kind which Mr. Fell has told us is so well suited for the opening up of a new country, and which can be made at a cost so much below what we are accustomed to think of in connection with similar undertakings at home.

There are various opinions on this point. I know some persons object to the idea of a railway. I would fain believe that this is because they have not been made acquainted with the feasibility of constructing a system of light railways in the country, such as described by Mr. Fell; but I fear that the objections of many arise from a preference to let the trading operations continue in their present form, from motives which are not altogether disinterested. Others say, "Make roads, and use bullock wagons." Some advocate the training and utilisation of African elephants for carrying purposes, and camels have also been recommended as beasts of burden. To arrive at the relative merits of any one of these means of transport, as compared with the advantages of communication by railway, we must consider each separately.

Transport communication with the East Coast is now conducted by means of what are known as caravans. These are really a party of men who carry the goods on their heads. They start from different points on the coast, and are conducted by Arab half-caste traders, who make their journeys into the interior at fixed periods, and usually occupy about seven months in the journey to and fro. They take such goods as are required by the natives, and barter these for ivory and such products as are of sufficient value to justify the enormous cost of this mode of transport, one commodity being nothing less than that of human beings, which, with ivory, have been found the only merchandise that could remunerate these parties for such an expensive mode of transport. Bishop Steere, Dr. Livingstone, and other missionaries, as well as Mr. Cotterill and Captain Elton, have vividly described the painful scenes they have witnessed in the conduct of this trade. They have told us how the poor creatures are brought in chains to the coast, and that only one out of ten is brought to the coast alive. Generally they are made to carry, in addition to their chains, the loads of ivory obtained by the party in the interior. The difference between the value of goods at the coast and at the Lake Districts, is said to be as much as 400 per cent. A piece of cotton cloth, worth at the coast 9d. per lb., has increased in cost at 500 miles in the interior, to as much as 3s. per lb. Under this system, the European merchants are at a great disadvantage, as they have first to sell their goods to the Banyans (who are settled at the coast towns, and who organise these Arab trading expeditions into the interior), and have to take in exchange the goods collected by the expedition on its return to the coast. A charge of 72 per cent. per annum is added to the value of the goods by the Banyans for their services. The great necessity, recognised by the white merchant, is the formation of trading stations, and the establishment of a system of direct dealing with the consumer in the interior. This, however, seems impossible, under such a very primitive mode of transport.

The construction of roads, and the use of bullock wagons has been advocated, and a practical attempt at their use was made by the Rev. Roger Price; and though at first apparently successful, afterwards proved a failure. Those who advocate this mode of transport seem to forget that there is such a formidable foe as the "tsetze" fly abounding in these regions, its sting being fatal to the bullock. In the face of this insurmountable objection to the use of bullock wagons, it is almost needless to offer any further argument, showing the utter impracticability of this mode of conveyance. It is due, however, to its advocates that additional reasons should be given why it cannot compare with the iron road and steam horse as a carrying power, and the more so as it is not an unfamiliar mode of carriage in many other parts of the world. To conduct traffic by this mode, roads through the country would have to be made, with bridges crossing unfordable rivers, and these kept in repair. Bullocks and wagons would have to be purchased, the former frequently replaced, and the latter kept in working order. Stations at frequent intervals would have to be provided, for feeding the bullocks and supplying fresh relays, and these of no small capacity, since each wagon, as proved by experience in the Cape Colony, requires a team of no less than 12 to 14 bullocks.

By the present system of barter trade, in the regions we are dealing with, the amount of goods these wagons could convey for sale must be limited, as provision has to be made for the carriage of material required for the purchase of food and

provender; thus the cost, which is said to be 2s. 6d. per ton per mile in the Cape Colony, would, in all probability, be double the amount in this district.

Rather than use any further arguments of my own in attempting to point out the inexpediency of this mode of transport, I prefer to quote the words of an article which recently appeared in the journal "*Iron*," in reference to the present mode of conducting the transport communication in South Africa:—

"Owing to the almost entire absence of railways, the shocking state of the few roads that radiate the immense circle of British colonial possessions, and contiguous friendly States, the natural obstacles presented by impassable and unbridged rivers and streams, the want of proper trading stations along an interminable length of country, trade is carried on in a feeble, childish and vacillating manner, dependent, more or less, on the seasons, and the freedom from sickness both of drivers and oxen. The trader's life is one of constant delay, and vexation, and mishap. His oxen, perhaps, all die on the road of long sickness or overwork, and he has to wait a considerable time for a fresh team; or he has constantly to unload and reload his wagons, which have stuck fast, up to the axle-tree, in moist sand, and which he has to dig out with spade and shovel. Again, having arrived at some river or deep gulley—perhaps not more than twenty yards across, or even twenty feet—which some distant rains up-country have, in a few hours, changed from a fordable and pleasant stream into a river of great volume and ungovernable fury, he finds his passage barred, and has frequently to wait on the wrong bank, idly kicking his heels for a couple of days, or, it may be, a couple of weeks together. This difficulty forded over, the trader's way may be monotously followed until he arrives at some large river—like the Orange and the Vaal—where he has to wait his turn, with a numerous company of other traders, to cross the river in a pont, worked by means of a chain suspended across the river. Landed at the foot of the opposite bank, it may still take hours for his wagons to effect an exit up the steep muddy bank of the great river."

Supposing, however, that the roads, bridges, and passes were perfect in condition, in gradient, and in evenness of surface, and equal to any of our best macadamised roads, the amount of wheel friction is so vastly in excess of that which is required to be overcome by the use of an iron road, that there can be no comparison in the relative powers of the animal as against the steam machine, cost for cost. Another very important item of consideration is the length of time required to make the journey from the coast to the interior, and *vice versâ*. I suppose it will not be incorrect to say that the time occupied in journeys by wagon from the Lake regions of Africa to the coast will occupy at least seven months, Without pursuing further the consideration of bullock waggons, I will dispose of this means of transport by again reminding you of that fatal objection the tsetse fly.

Captain Burton is of opinion that a large ass, which is to be found in some parts of East Africa, might be made available, and he thinks that it is too hardy to be immediately affected by the fly. Assuming, however, this to be the case, and that this animal could be used in pulling wagons, all the objections to the bullock wagons would apply.

We find others advocating the training and use of the African elephant as what I suppose may be termed a pack-horse. When trained, there can be no doubt, the elephant will prove an important aid in feeding a main trunk line. In such work it will only be called upon to traverse comparatively short distances, and many of the inconveniences which would otherwise attend its use would be avoided; but, as a matter of economical carriage, it can scarcely be said to come up to the desired standard.

Sir Garnet Wolseley reports that an elephant weighs three tons. It can carry 15 cwt. That, with rations and men to attend it, it will cost 13s. per day, for which it will carry one ton 12 miles, or, in round numbers, say one ton at a cost of 1s. per ton per mile. In the estimate must be added the first cost of the elephant itself. It is a delicate animal, and in temper cannot always be relied upon. It is stated that no roads would be required, as the animal makes his own track. Granting this much in his favour—we find, even omitting the cost of his purchase, that to carry goods by his aid would mean a cost, for a distance of 500 miles, of £25 per ton. Why, I venture to ask, if the elephant is so economical a vehicle of transport, has his use in India been so largely substituted by that of railways?

The same remarks apply to the camel, with, perhaps, the additional fact that this animal suffers severely in the feet from passing over a rough or stony road. Livingstone tried camels in 1866, but lost those he took in a very few weeks.

Mr. Thomas Newbigging, of Manchester, in speaking of his experience of the pack-horse in Brazil, offers indisputable evidence of the great desirability of railways in that country in lieu of the horse. He says:—

"Brazil, which is a magnificent country, with every natural advantage in the way of soil and climate, has tolerably good roads in every direction, but its backward condition, and its inability to compete with the States as a cotton-growing country are due, after slavery, to the want of railways into the heart of the cotton-producing districts in the interior. The bulk of the produce of the country is brought down to the coast on the backs of horses at an enormous expense. Each animal carries two small bales of cotton, and it is estimated that the proceeds of the sale of one of the bales barely remunerates the planter for the cost of the carriage of the two a distance of under 100 miles. If any immediate or early success is to attend the present African venture, it will be by the formation of one or more lines of railway, carefully and economically constructed and administered. Roads are desirable, but railways are indispensable in such a country."

Without leaving the Continent of Africa, I may ask how it happens that, in the Cape Colony and Natal, bullock wagons are being superseded by the construction of railways? It surely must be that the enterprising spirits of these colonists have been convinced that the iron road is necessary for the successful development of their country. Railways are partly made from Cape Town, Port Elizabeth, East London, and Durban. The opening up of that newly acquired British Colony, the Transvaal, is also said by its inhabitants to be entirely dependent upon the construction of a railway from Delagoa Bay to Pretoria.

In the West Coast of Africa a concession has been granted to Mr. Criswick by the Liberian Government, for the making of a railway to a distance of 200 miles inland, in order to carry to the coast the rich products of that portion of Africa,

among which may be mentioned the renowned Liberian coffee.

If we come home, I cannot imagine anyone in this country suggesting a return to the days of pack-horses and wagons in lieu of our railway system. The days were when the coal was carried in the mine from the working face to the pit shaft on the heads of young women, who then descended into the mines, and I have been told by one of my own men that he married his wife "because she was a better carrier than any other wench in the pit." Now all this is changed. Females are not allowed down the pits. The coal is carried on rail or tramways, and in collieries in which I am interested myself there are many miles of this kind of railway underground. I cannot better illustrate the value of railway communication, than by quoting, as an example, a valuable coal-field, with the development of which I have the honour to be credited; and perhaps I shall not be presuming too far in accepting the credit of this, inasmuch as I believe I was instrumental in the construction of a line of railway, which connected the field with the main line of the country. The absence of such a communication would have been fatal to the successful development of this coal-field; for if the coal had been carried by wagons drawn by animals over ordinary roads, the cost per ton would have been from one to two shillings per mile for the distance to be traversed; and such a limited trade would have been the consequence, that it would not have paid to work the coal. But by the aid of the railway, a large trade has been done—half a million tons of coal annually pass over this line; and the cost, instead of shillings, does not exceed 1½d. per ton per mile. The country, which was chaos before, or, at the best, a quiet agricultural country, is now a little town, full of life and "go." It has its gas-works, its water-works, its market-house, its little Parliament-house, and all the belongings of a thriving locality. This is simply one instance, and compared with many others in our own country, a very modest example of the development of the natural wealth of the country, and the establishment of an industry due to the advantages derived from a railway transport communication. From my own knowledge and experience, I could quote many other examples, but I cannot suppose it is necessary for me to do so, as many present will have had similar experiences, and our business is rather to consider the applicability of railways to Africa.

I think most will admit that Mr. Fell has pointed out to us a system of railway which can, without any difficulty, be applied to Africa. He has also set before us, in ample detail, the method and feasibility of constructing a railway of this kind in that country, and has made it quite clear to us how such a railway can be worked; and he has fully proved to us that goods can be carried over such a line at a cost not exceeding 2½d. per ton per mile, this cost per mile including 10 per cent. on the outlay. Now, if we set this cost of 2½d. per ton for goods carried by rail, against that of 2s. 6d. per ton for the conveyance of goods by bullock-wagon, or even against that of 1s. per ton if carried by elephants, we find that the enormous advantage in favour of a railway is that it makes possible a lucrative trade in a very large number of the natural products of the country, which could not possibly pay for any other available means of carriage, whether by elephants, bullock-wagons, camels, or asses.

A further important advantage in favour of the railway will be found in the fact that its food will be much more easily obtained on the way. It will not have to carry goods to barter for this food, and it can carry in 24 hours that which, under the other modes of transports which I have named, will require almost as many weeks.

The planting, so to speak, of a railway in Central Africa would benefit, and generally consolidate the influence of the legitimate powers, such as the Sultan of Zanzibar on the East Coast, and those chiefs in the interior who prove themselves friendly. It would carry civilisation into the country at "railway speed." It would act as a connecting link of one common interest of tribe with tribe. It would inspire the native with a respect for the mighty power of science. It would teach him more rapidly than any other known means—what he is already, to some extent, conscious of—how far he is "behind the times." It would cause him, in his wonderment and awe, to forget the petty disputes with his neighbour, and thus act as a general peace-maker; and, while inducing him to protect the part of the line passing through his portion of the country, it would excite in him a strong desire to partake of its benefits, and so promote him to be an industrious cultivator of the soil of his country. It would, above all, put an end to that abominable traffic in human flesh by substituting legitimate trade. And, with all these blessings to the country through which it passes, by opening out these new fields of enterprise, and providing new markets for English manufactures, it would give a new life to the industries of our own country. Employer and employed alike would be benefited—and whilst each in his way aided in the promotion of the great work, each would receive his proportion of recompense.

I have not entered upon the question as to the supply of raw materials, such as cotton in particular, which could be secured to our country by the development of the cultivation of such products to their utmost extent. This feature would in itself provide matter for a paper. May I, however, ask if that fine cotton field which is said to lie between Lakes Tanganyika and Nyanza could be cultivated to its utmost extent, might not our own country obtain a supply of cotton of a superior quality, at prices much below those now ruling? I am not acquainted with the cotton trade, but it seems to my common understanding that this is well worth a thought. It remains now only to consider the application of a railway system to Africa, and especially to that portion which is described as so rich.

The general opinion seems to favour the commencement of a line of railway at a point on the East Coast, and carrying this inland in the direction of Lake Victoria Nyanza, and so aiming at tapping that rich and thickly populated country which surrounds the lake. A branch from this railway might also be carried into Lake Tanganyika. It would appear, perhaps, the wisest course to proceed by stages of, say, 40-mile lengths, and, as each stage becomes a well established institution in the country through which it passes, to proceed

with the following stages until the important points named are reached. To make use of the water-ways, link lines might be constructed by the aid of which the cataracts could be passed. Thus, if it is desired to penetrate Africa from the West Coast, the Congo river might be navigated with the aid of such link lines of railway made past the cataracts as shown on Mr. Fell's plan, the first of which would be a length of about 200 miles, and the second only 30 miles. We should thus have an excellent transport communication along this course, composed of 230 miles of railway, and more than 2,000 miles of water-way, which would bring us right into the country surrounding Lakes Tanganyika, Moero, and Bangweolo. The Shiré River and its rapids of 60 miles might also be treated in this way, and by constructing a line of railway to connect Lake Nyassa with Lake Tanganyika, a distance of about 150 miles, we should have an excellent transport communication established along that course, consisting of a total of 200 miles of railway, and 1,200 miles of waterway, which brings us to the north of Lake Tanganyika.

It would only be deceiving ourselves to act on the presumption that difficulties would not be encountered in the carrying out of the work indicated. Difficulties will present themselves; but, if we are true to our reputation as "Britishers," we shall simply see these difficulties to overcome them. The path by which we added India to our empire was not a smooth one. The hostility of the natives of some parts of Africa is feared by some, but surely if parties of traders can travel the country, cut off from their base of supplies, is it too much to expect that a line of rail and steam communication, which, perforce, has a continuous connection with its base of supplies, would in itself prove a power capable of defying any hostility? I decline myself to recognise as at all insurmountable any of these supposed difficulties, and will now ask you to look at the map of Africa, and imagine such a line established between a point on the Zanzibar coast, and Lakes Victoria Nyanza and Tanganyika; another such line running from the mouth of the Congo on the West Coast to Lakes Tanganyika, Moero, and Bangueolo; and a third northward, from the mouth of the Zambesi along the Shiré river to Lakes Nyassa and Tanganyika, and you will find that these will form three main trunk lines for transport communication with Central Africa. Each of these main lines would be provided with suitable trading stations, fed by navigable river steamers on the lakes, and, where suitable, by the aid of elephants or such beasts of burden as are practicable. We shall thus find Africa provided with a transport communication of the most perfect kind, supplied at a moderate cost, possessing a carrying power unlimited in its capacity, and at a speed which is not to be secured by any other known means.

Is the work worth doing, or is it not worth doing? is a question that can only receive one answer from the far-seeing patriot. If, therefore, worth doing, is it too much to ask that it be done in the best possible fashion, on the principle that "what is worth doing at all is worth doing well?" Many are alarmed at the supposed expenditure upon such an undertaking. I would remind these that, in the plan laid down, the cost will be much less than they suppose. The work will be progressive, and advanced as the circumstances justify. Once, however, having adopted such a means of transport communication, the progress must be more rapid than under any other.

It need scarcely be asked, "What does England owe to her railway system?" nor need I remind you that millions have been expended upon her railways. Some of her main trunk lines have capitals of sixty millions, fifty millions, and thirty millions sterling respectively, and it is common to find many of the smaller systems have cost as much as ten millions sterling. Surely, then, the few millions, which will be expended upon securing the enormous advantages to be derived from the application of a railway and steam transport communication with the "rich tropical regions of Central Africa," should be willingly contributed by those who are interested in the good of their fellow-men, and in the prosperity of their own country.

DISCUSSION.

The Chairman, in proposing a vote of thanks to Mr. Fell and Mr. Morrell for their very able papers, said this was a most important question, bearing as it does upon the opening up of a vast continent, and of the richest part of that continent. He had been in South Africa and all over the Cape Colony scarcely a year ago, and had there seen less fertile districts traversed by more than 1,000 miles of railway, and he could not doubt that when the time came for opening up these equatorial regions, which were filled with the most valuable products, it would afford a rich return for the money invested. Besides that, it would be contributing to the great work of civilisation among a people who could hardly be civilised in any other way. Missionaries were sent out, but they did very little. He believed the real way of civilising and evangelising a people was to introduce to them the idea of respecting their own labour and of working to a useful purpose. In short, commerce was the great civiliser of humanity. There was a great incentive in this country to such works at the present time, for no one acquainted with any branch of industry, manufactures, or commerce, could do otherwise than feel that there is a want of some new continent to which to send goods. We had been beaten in many of the markets of the world, which were formerly our own. We no longer sent rails to America or to the continent of Europe—for the manufacturers there not only competed with us in their own countries, but also in other lands, and we therefore wanted fresh continents to attack in this peaceful manner. He had the pleasure of seeing in the room that evening a gentleman from China, and that reminded him that his country was one of those which needed railways. It was a great country, overflowing with population and wealth, and above all others it wanted railways, and as soon as the gentlemen in China would allow us to help them in that direction, no doubt it would be done. He saw before him another gentleman, who had been very early in that field of enterprise, having been instrumental in the construction of a short railway in China, but already, he was sorry to say, the line was defunct, and had been removed to the island of Formosa because the Chinese would not have it. He was sure, however, that some day they would change their views, and welcome railways among them. Coming back to Africa, it occurred to him that some of the plans put forward were rather extensive, but if they were to begin by making a railway from some point on the coast to one of the great lakes, it would not be so great an enterprise, and there would be a line with an ocean at one end, and this vast inland sea at the other, around which there was a

large population, and where much commerce might be expected to be developed. That was the way in which it appeared to him that an inroad must be commenced. Mr. Morrell had properly pointed out that the employment of camels, asses, bullocks, and elephants, was really ridiculous in comparison to the railway. He, himself, had seen bullock-waggons in South Africa. They never went with less than 16 bullocks, and when they came to a river they often got stuck, and had to put on two teams to get the waggon out. As to the form of the railway, no one had had more experience than Mr. Fell in devising the means of making railways on a cheaper scale than those we were accustomed to here. He had followed his endeavours for many years, from his first great undertaking at Mont Cenis, where he had the pleasure of accompanying him on the first engine which went over the line, and he knew that no one was more capable of advising on these subjects. The remarks which had been made with regard to Mr. Haddan's railway, he must, to a certain extent, coincide with, for he knew how very warm Mr. Fell was at first in favour of the very system which Mr. Haddan now advocated, and that it was only by experience that he came from the one rail to the two. He believed that the two-rail system was the one which must, under all circumstances, be adopted, as being the most workable, and, in fact, the most economical. Being obliged to leave, he would ask the Treasurer, Mr. Cobb, to occupy the chair for the remainder of the discussion.

Mr. Hale thought that the only practical way of carrying out any scheme would be to make a short section first. Even supposing a line could be made at one-fourth of the cost of an English railway, it would still require one-fourth of the English traffic to make it pay, and he doubted where that amount of traffic would be found in Africa for some time to come.

Mr. H. C. Richmond (of Southport) requested that the following remarks should be communicated in his name—When the making of a railway into the interior of Central Africa is suggested, there are some whose minds revert to the fact that there are railways in other parts of Africa, that is to say, in Egypt, Algiers, and British South Africa. However, it is not possible to institute a comparison between any of these and the proposed railway into Central Africa. Algiers is a very poor country indeed compared with the well-watered central portion of the continent. An extended railway system in Egypt is an absurdity which could never have entered the mind of anyone but an extravagant Pasha. The land of Egypt, if we exclude the Nile delta, is only some ten miles wide, and has a splendid waterway running through it from end to end. To make railways where abundant water communication exists is wholly ridiculous. In British South Africa the railways from Capetown to Beaufort, Durban and Pietermaritzburg, &c., are made on a totally different plan to that which we venture to think is the only suitable system for such a new country as the interior of Central Africa. Thus no comparison can be set up between any of these and the proposed railway from the eastern coast of the continent. One enormous advantage of making a railway over the use of any other means of communication is this: it will enable the European merchant at Zanzibar, Bagamoio, Mombasa, or Kilwa, to get change of air from the low-lying coast to the healthy lands of the East African plateau, 4,000 feet above the sea. This, for Europeans living in such a climate as that of the East African coast, is a matter of the greatest importance. When any of the European merchants resident in Alexandria or Cairo, in Calcutta or Madras, need a change to a more bracing air, they do not come home to England. That is a change only to be obtained once every few years. They go to the uplands; the merchant from Alexandria takes the steamer to Beyrout, and spends two or three weeks on Mount Lebanon, while his brother merchant at Calcutta takes the train for Simla, or goes up to Darjeeling for the mountain breezes. They both return recruited in health for the next twelve months. And in this way the proposed railway from Bagamoio or Saadani up the flank of the East African Ghauts will be of untold benefit to the East African merchants. Mpwapwa and the Rubeho mountains will be a sanatorium as accessible for merchants at Zanzibar or Kilwa, as are Darjeeling, Simla, or Ootacamund, to the people of Calcutta and Madras. If Englishmen are to influence the East Coast, whether as merchants, or even as officers on the cruisers in the Mozambique Channel, they must have a sanatorium, and this the railway will provide; and no other means of communication possess this great advantage of providing rapid access to a great sanatorium. Another incalculable advantage of a railway over any other means of communication in Central Africa is to be found in this consideration, that the railway and the railway alone will enable the European to compete with the keen trading instincts, and economical personal expenditure of the Banyans and Hindis in the coast towns. I used formerly to think that it was a terrible calamity for Africa that the tsetse fly prevented the use of horses, asses, bullocks, &c., as a means of transport, and I well remember the joy with which I read the intelligence prematurely sent home in 1875, by Mr. Roger Price, of the London Missionary Society, that he had taken a team of bullocks from Saadani up to Mpwapwa, and brought them back in perfect safety, thus showing, as he thought, that a route had been found free from the dreaded tsetse. As things are, however, I have lately come to the conclusion that the tsetse fly is a very real blessing in disguise, and for this reason. If it were possible to utilise horses, asses, camels, elephants, or bullock teams, the Banyans would completely "cut out" the European merchant, if I may use a colloquial expression. He can live at one-tenth the expense of an Englishman in Central Africa, and would be able to buy teams of bullocks, &c., as so, if legitimate trade is to be introduced into the interior, the Banyans would have to be the people to introduce it, and not the white merchant. Need I for one moment suggest how much greater a benefit will result to Central Africa if Englishmen and the civilising influences they bring with them (for we could keep out the rum and gin of the West Coast) penetrate the Continent, rather than the keen and merciless Banyan, the ally, and indeed the principal, of the Swahili Arab slave trader. A great company, which cannot be formed without taking the railway proposed as part of its programme, can successfully compete with the Banyans, and make them, by means of the railway, a paying part of the scheme. In saying "a paying part of the scheme," I mean that their Arab clients will still continue to trade with parts beyond the influence of the proposed trading corporation, and these Arab caravans will assuredly use the railway rather than take six months as at present from Bagamoio to Unyanyembe. There are two parts of the coast of Africa where there is a native government able and willing to grant to any company taking the risk of being the first to make a railway into the interior, a guarantee against competition for a reasonable number of years, until those who took the first risk have reaped the full benefit of "pluck" and far-sightedness. These are the Liberian Republic on the West Coast and the Sultan of Zanzibar on the East Coast. The territory of the Liberia, the finest coffee-growing country in the world, stretches along the coast for 400 miles or more; that of the Sultan of Zanzibar extends for 1,200 miles on the East Coast of the Continent. Both are most desirous of the construction of a railway, and the Liberian Government have already granted a concession to Mr. H. C. Criswick, whose scheme seems to me to have in it every element of complete success, and to be deserving of the most favourable consideration and cordial good wishes. I only desire further to add that Central Africa, if opened up to trade, will take from us a steady and

rapidly increasing quantity of silver coin. The chiefs already know something as to the use of silver coin; and I may remind you that Mtesa, King of Uganda, has a good large quantity of silver coin at present stored up at his capital. This, I state on the authority of the Rev. C. T. Wilson, formerly of Manchester, and now resident for nearly two years at Rubaga, the capital of Uganda. In this respect, I mean as a silver-using country, I trust that Central Africa will very speedily become more than a nearer India, and thus be of incalculable assistance in relieving the financial difficulties and anxieties of the Government of India, a country which is alike the home of the Hindi and the Banqua, and the brightest jewel of the British Crown.

Mr. J. L. Haddan said—The question raised by the author as to the proper means to be employed in developing new countries, by the conversion of their forests into animal power (by the use of steam), is naturally one little understood in England, where the conditions to be met by the engineer are quite dissimilar. Mr. Fell considers the question can be met by palliatives, and attention to details, such as narrow gauge, maximum grades, and so on, although the profession, as a whole, have now learnt from experience that all these attempts to construct cheap, light railways have proved the most disastrous of commercial failures, the delusive reduction in first cost being obtained at an ultimate sacrifice, due to, firstly, increased working expenses, attributable to the use of prohibitive grades caused by scamping the banks and cuttings; secondly, to the endless *détours* resorted to for obtaining easy ascents; and, thirdly, to cheeseparing economy in using unduly light rails, and so on. The author will not, however, it seems, profit by such dearly-bought experience, and suggests the use of the ordinary railway, *pur et simple*, elevated upon posts, with the laudable idea of non-interference with nature—the only point in its favour, and one by no means peculiar to his system. The vices of the ordinary railway are not only reproduced in his system, but positively augmented about fourfold, since the grades cannot be improved so readily as with banks and cuttings, which are double-acting, as it were—the cutting lowering one end of the grade while the bank rises to meet it at the other extremity—while Mr. Fell's continuous viaduct necessarily acts like a bank, and must either be twice the height to obtain the same grade, or else charge the future with fourfold the working expenditure, due to the grades being twice as bad. What all engineers want to do is simply to skim over the surface of the soil and thus ignore its difficulties, and compete with the animal transport by being able to take as short cuts as they can; but no one pretends that this can be effected by employing the gravity engine as Mr. Fell does, for we have endless examples to the contrary. To rely upon gravity—a power whose action is downward—to obtain either upward or level motion, is simply ridiculous, when applied to anything but first-class railways, the maximum grade on which was fixed by George Stephenson at 1 in 300. What would his disgust be to find his engines forced to work out of their element on grades of 1 in 30, as practised by the author and others, but certainly never intended by the inventor. The disparity or loss between working 1 in 30 and 1 in 300 is 100 fold, and commercial failure under such conditions should surprise no one aware of them. It is only owing to cheap coal and unlimited command of mechanical talent that this serious departure from Stephenson's principles has not forced itself upon our notice at home, as it has done in out of the way countries less favoured than ourselves, either as regards their geographical, mineral, or financial position. If we are to override physical difficulties of country without altering them at the usual prohibitive cost, we must adopt principles of traction which command the steepest natural slopes of the country in question, and not employ a system subservient to all but the most exceptionally flat, such as those on which our first railways were bred and born, and for which, unmodified, they are alone suited. Fortunately we have such a system at our disposal, and one which has, in a measure, proved a great success. I refer to the continuous brake, which aims at conquering in detail a force which has been rendered all but unmanageable by the use of gravity engines and brakes. Now, as rest is but the reversal of motion, the same mechanism applied to induce motion in each wheel of the train, is a most natural consequence of this successful attempt to distribute brake effort throughout the train. The advantage in adhesion offered by continuous driving is extraordinary, being as 7 to 300 in favour of a self-propelled load against a drawn one; and if Mr. Fell or any one else wishes to adopt an elevated railway, raised above the ground only sufficiently to leave tropical water full play, and obtain, as I do, a line capable of following the crow's flight in rough country, and yet not attain its economical working limit, he must adopt my system of combining an elevated structure with a self-propelled train, in which both concentrated gravity or effort are eschewed. When concentrated weight has proved so disastrous on *terra firma*, what chance has it of success applied in *nubibus?* Sir Henry Tyler, than whom no one possesses greater knowledge of English railways, dubbed Bosnia an impracticable country, and very justly so, as regards Mr. Fell and his compeers; but are such countries going to accept isolation from civilisation because our motto is "*Aut Cæsar aut nullus*"—the English railway or nothing? There are whole continents in a similar position, and our profession will, let us hope, mark the pertinent remarks offered by Colonel Stanley, Mr. Lowe, and Sir Michael Hicks Beach, at our annual dinner, for they all three inculcated the same lesson. Colonel Stanley, no doubt fresh from the perusal of returns of the irremediable loss of animal power lately experienced in the Zulu and Afghan campaigns, reminds the profession that although the condition of a great portion of our vast empire brought us face to face with primeval times, as regards transport, we had nothing suitable to offer. Mr. Lowe followed suit, and blamed us for so abjectly treading in the footsteps of our fathers, whose rapid success had intoxicated the universe, but whose varied demands have not been met, except by a stereotyped system. Sir Michael Hicks Beach, referring to the commercial failure of colonial railways, gave the *coup de grâce*, when he reminded us that the vast area of the colonies, and their inversely small means, called for anything but the grandiose treatment of our mammoth English lines, the charges to support the mechanical luxury of which, it cannot be denied, are fast destroying our export trade. Wages are reduced, hours are lessened, but railway tariffs (as much an export tax as if levied by the Customs), still maintain a price which might be reduced more than one half if economical principles were employed. The existing wasteful railway which, under a different and still more delusively attractive form, is offered you by Mr. Fell, is guilty of the present depression of trade. The vast sums confided to our possession for making railways to extend our markets have been sunk in unprofitable railways, and not invested in creating means of communication, the immediate profits of which would have pushed railways on at a pace commensurate with our industrial production, and not have come suddenly to a full stop, leaving all the markets of the world glutted, and no outlet possible. I will conclude these general remarks by reminding the author that railway construction, to be economical, must be designed quite as much to meet the actual requirements as purely technical ones. Hence, to obtain a fair comparison between any two or more systems, the durability of the materials is a most essential feature, the costs of repairs and working expenses should be capitalised; for the cost per mile is utterly unreliable, as it neither illustrates the length or quan-

tity, nor the quality, nor the durability. One example. The abolition of earthworks means, in the case of an ordinary road or railway, a saving of annual maintenance equal to a minimum of £1,000 per mile capitalised, and to a maximum of over £5,000 in tropical countries, where the yearly rainfall falls in a few days or hours. The prize is, therefore, offered to an elevated railway; but, as I explained before, it cannot be attained on Mr. Fell's system, except at a fatal sacrifice of efficiency. It is not surprising that in the face of recent railway investment failures, the general public should cry down railways and put their trust in animals, which are quite as unreliable, however, as the proverbial princes. The bare idea is retrograde, for steam properly applied can beat animals hollow. African climate is against their use, and their concomitants, roads, which never can pay commercially, because the wear and tear on them, as upon a tramway, is mostly due to extraneous causes. If we would avoid Zulu difficulties, we must take General Hamlin's advice, and fight with railways and concentrated forces which awe, instead of employing small bodies whose numbers excite our enemies to try conclusions with us. Should such lines be made, at least, to our frontiers, in lieu of depriving our own provinces of their animal transport, and offering bare money as compensation, we can literally convert our swords into ploughshares, or rather fight with them, if we push our advances of civilisation slowly forward, leaving the indelible track of the railway behind them, as some small compensation for the injury to trade incidental to war.

Mr. R. G. Elmes said he was an advocate of light railways, and if time permitted he should have liked to reply to some of the last speaker's observations. On the question of gradients, it was quite true that it was more expensive to work a steep gradient than a light one, but it was simply a question of burning so much more coal. Out of a pound of coal you got so much mechanical work, and taking a given train and a given gradient you must do so much work, and it did not make a material difference whether you did it with an ordinary locomotive, with the weight spread over a certain number of wheels, or by a central rail. The objection to a central rail was that it was a complicated thing to work, and it had given a great deal of trouble on the Mont Cenis railway. With regard to the opening up of a new country with a railway, no doubt at first sight it appeared like putting the cart before the horse, and one would naturally suppose that the first thing to do would be to make metalled roads. He was not at all wedded to railroads, and was in favour of using water communication wherever it was available, but in the case of the railway in Africa with which he was connected, they had to get up to a tableland 2,000 feet above the sea, and therefore a canal was out of the question. He had also had a good deal to do with roads, and the cheapest metalled road he had made was one with gradients of 1 in 5 over the Himalayas, which cost £1,000 a mile, whilst the most expensive were some of the streets in London, the paving of which cost £14,000 a mile. He had also had to do with some of the roads in India, and it was found practically, that where there was a fair amount of traffic, it would cost almost as much to make a metalled road, in the first instance, as to make a railway, and a great deal more to maintain it. After all, that was not very extraordinary, because a metalled road must be at least 16 feet wide, whilst a railway of 3 feet guage only need be 10 feet. Again, if you were to get the full power out of the horses or bullocks, the gradients must be almost as good as on a railway. He once built a bridge in India where the approaches were 1 in 100, but the Government, for the sake of economy, reduced them to 1 in 50; and the consequence was that all the carts went through the river instead of over the bridge, except when there was a flood. The cost of transport was so great that they loaded the carts up to the very maximum the bullocks could draw on the level, and thus they could not get over this gradient. Then again, the cost of carriage on a metalled road was never less, under the cheapest circumstances, than three times the cost by railway. He was rather astonished at Mr. Fell's estimate of 2d. per ton per mile, for his experience would have led him to believe that it ought not to be more than 1d.; but if it were 2½d., the cost of other carriage would be about three times as much probably. Then there was the question of maintenance. Tolls were a most expensive way of raising a revenue, were often evaded, and caused great discontent For all these reasons it seemed to him that a railway was the most feasible means of opening up communication. As to the cost of a railway, he was an advocate of light railways, as he believed many other members of the profession were. The whole of the new State railways in India, except a few which were made on the old system for strategic reasons, were on the light system, and it was now being adopted in all parts of the world. He had been examining some steam tramways—which were really light railways—in Italy, laid down on common roads, at a cost of from £2,000 to £2,100 per mile; they were worked at from 40 to 50 per cent. of the receipts, and were bringing in from £10 to £12 per mile per week, and, as far as he could see, were thoroughly satisfactory. He could not imagine why anyone should say that light railways were given up as a mistake; on the contrary, he ventured to think that, in the future, heavy railways would be in a minority, and regretted that in the Colonies they had been going in for such expensive lines. The proper way was to lay down a light railway first, and when the traffic increased make it heavier. Some years ago, the ordinary rails used were 40 lbs. to the yard; but he was now laying down a line in Lancashire with 84-lb. steel rails. In the case of the proposed African line, they intended to adopt the general dimensions of the Indian State railways—3 ft. guage, 40-lb. rails, and the engines weighing about 6 tons to the axle—and to make it, as much as possible, a surface line. From the information he had as to the nature of of the country, the cost of labour, &c., he believed such a line could be made, with proper management, for about £4,000 a mile; and he also believed that, in a short time, there would be traffic of £10 to £12 per mile per week, which would pay reasonable interest on the cost of construction.

Mr. Rapier said that, as Mr. Haddan had thrown out a doubt whether a light railway could be made to pay, or to answer at all, he might mention that it had occurred to him to make the smallest locomotive that could be made, to travel 20 miles an hour, and carry a few passengers. This little engine, when finished, and filled with water and coals, weighed 18 cwt., and, upon one occasion, when the carriages behind it were crowded with 80 passengers, it still went 12 miles an hour. He would, therefore, advise all friends of light railways not to be frightened by tall talk, but to make engines small enough, and keep down the cost as much as possible in countries like Africa, and then they would be a success; but to avoid going upon stilts, and to keep to the flat as far as possible, which was what George Stephenson always advocated.

Mr. J. C. Leaver (secretary to the Cape Copper Mining Company) said his experience entirely bore out the statements of Mr. Fell and Mr. Morrell. They had actually a railway in Cape Colony 93 miles in length, and their experience with it had been exactly what was stated. Previously they could not convey more than two tons of ore in a waggon drawn by 14 oxen, and as the mines increased, it was not only too expensive, but utterly impossible to get any quantity of stuff down. And now that copper was so low, if it had not been for the railway they would have had to close the mines. The line had not cost £1,750 a mile, and they had to

cross a mountain range and land themselves 3,000 feet above the level of the sea. They had now had ten years' experience of it, and it was thoroughly successful. They did not use locomotives on it, but he believed that for another £250 a mile they would be able to do so. When projecting this line they had all sorts of schemes brought before them, some recommending them to go up in the sky, and some down under the earth, but they thought that as the Almighty had given them the ground, they had better stick to it. One engineer brought them a scheme which would have cost £80,000 for a third of the distance, and the general idea seemed to be that because they could not walk they must attempt to fly. The worst gradient on the line was 1 in 20; they avoided difficulties of that sort by going round them. The question of girders or earthworks was one of detail, but their experience showed that a line could be made for £2,000 a mile, which would carry an engine powerful enough to be economical.

Mr. Fell explained that he did not lay out the line at Aldershot, and that it was made in the direction shown ou the plan in order to meet with viaducts and gradients, as an experiment. Where the ground was sidelong, you need not have one side of the structure longer than the other, because you could dig a slight trench, and make it level. Mr. Haddan said that having all viaduct you doubled the height, which was true; but it was also true that you had only half the length, because for the other half you were on the surface. If what Mr. Haddan said could be done with his engines were true, he would admit there might be something in the plan, but he could not believe it until he saw it accomplished. Mr. Haddan said there were people who would build engines and guarantee that they would do their work; and having a small line in Italy where he thought this plan would answer if anywhere, he wrote to Messrs. Fox, Walker, and Co., and asked if they were prepared to build an engine and guarantee it to take the load Mr. Haddan stated. They replied that they would not do anything of the kind; that all they could do would be to build an engine which would carry about 12 tons. About a month ago Mr. Haddan gave him a pamphlet, in which he stated that the Yorkshire Engine Company would build engines to carry 200 tons up a gradient of 1 in 20, and if that could have been done it would be a vast step in advance; he, therefore, wrote to ask them if they would do so, and only yesterday he received a reply, saying that they had no arrangement with Mr. Haddan at all. He had taken a great deal of trouble to make this kind of railway answer, and the only way Mr. Haddan could settle the question would be by making au engine which would work, and he was sure they would all be delighted to compliment him if he succeeded.

The Chairman said the object of this Section was to develop if possible the interior of South Africa, and they were all indebted to Mr. Fell and Mr. Morrell for their papers. Canals in South Africa were quite out of the question, and if the figures given by Mr. Fell were to be depended upon, no doubt they pointed out the very best way of opening up communicatiou with these parts of Africa. Fortunately, they had had the personal experience of a gentleman, who had told them what had been done with the copper mines of South Africa, and that line certainly went through about as rough a country as any in the neighbourhood of the lakes.

Mr. Morrell, in acknowledging the vote of thanks, said that they meant to proceed by stages. They did not expect to do the whole work at once. They proposed, also, to take advantage of the water commmunication wherever it was available, but seeing that it was not available on the Nile, or any of the great rivers except the Niger, they designed to pass the rapids and cataracts by railway, taking advantage of the rivers where possible.

Dr. Mann drew the attention of those present to the fact that, at a meeting held by permission of the Council, in the Society's room, on the 23rd of April (St. George's Day), a society, to be designated the "Society of St. George," was constituted, to co-operate with the St. George's societies of Canada and other colonies, and of the United States of America, in establishing a closer union between separated communities.

Mr. Haddan has, since the meeting, written:—"May I be permitted to say, in criticising more closely Mr. Fell's estimate as to a daily traffic of 100 tons, that the statement is exaggerated. The Zanzibar returns give 20 tons. The Stanley Falls average a grade of 1 in 15, and, in general, the water-ways will have to be followed. Hence the ordinary railway is not available, except horse-shoe detours are indulged in to obtain even a grade of 1 in 50, and the insignificant train-load of 14 tons nett. In narrow ravines, winding about to obtain a good grade is, with the ordinary railway, impossible, but not so with the Pioneer. If practice shows that viaducts become more economical than banks of 30 feet high, how does Mr. Fell expect to obtain any economy in drawing the line at three feet instead of thirty, the cube of the one being as 1, to 100 in the other? Although every facility has been given to Mr. Fell to understand my Pioneer, he seems still to consider it identical with a design of his own which he abandoned, apparently in defereuce to his old friend Sir Henry Tyler's opinion that it would not work. Sir Henry Tyler has not seen my plans, but merely takes on trust Mr. Fell's modest assurance that they are identical with his own cast-off ideas. No engine was built, and yet Mr. Fell would condemn my system for no better reason than that he half tried something which looked like it. Mr. Fell clearly does not understand that brake power and driving power are the opposite of each other, for on the Mout Cenis, his grip wheels, when applied by hand in excess, as they always were, constantly overstepped the line of demarcation where adhesion ended and brake power commenced. Hence his failure to realise with the grip the advantages which are to be derived from its substitution for concentrated weight. Mr. Fell's criticisms are merely founded on facts; instance his statement that my system worked upon grades of 1 in 10 as a matter of choice, and not as a military necessity, for which alone such grades are intended, when a crow's flight line is wanted in rough country. The Pioneer, being able to command any grade, can do as it is told, and not baulk a General by detours and other mechanical excuses. Mr. Fell's calculations apply to ordinary railways and, consequently, to his own system, but do uot apply to mine, where the weight of the freight and the whole of the train affords adhesion, and not, as he puts it, the weight of the engine alone, as in his own case. All the illustrious persons referred to by Mr. Fell as having attempted elevated railways, could not possibly succeed so long as they used concentrated engine weight, for the structure could not be made strong enough; but the moment the tractive effort is distributed throughout the whole train, no part of which weighs more than 15 cwt. per wheel, however long the train may be, then does it become possible to attain an elevated railway, not high in the air, like Mr. Fell's, but only raised sufficiently to leave free water way, and enable the carriages to skim over the surface of the ground, in its natural state. Mr. Fell's experiments singularly bear out the condemnation of the narrow gauge for gravity engines. He began with one rail, then adopted 8 in., then 14 in., theu 18 in., and has now got to 3 ft. 6 in., and must come to the 4 ft. 8½ in., the reason being that concentrated weight is more readily attainable by breadth than by length. It is certainly impossible for him to run ahead like the Pioneer, and carry his own materials and stores with him. Even in ordinary country half

the viaducts would be of the type shown on the wall, 20 feet in height. The piers are all different heights, and the girders are not continuous, and therefore would require scaffolding, &c., while the Pioneer follows the undulations of the ground, so that it nearly always is within easy reach of a man, its normal level being 3 feet above the ground. My system weighs 80 tons per mile, and Mr. Fell's, I believe, 250 tons. Mr. Rapier has had great experience with narrow-gauge railways, and he admits that gravity railways in minature can only be made to work with reasonable economy so long as they stick to the flat, and keep within George Stephenson's limit of 1 in 300. How, then, could they suit the Dark Continent, Turkey, and other countries pining for steam caravans. Mr. Fell clearly shows his disinclination to leave the beaten track, for he knows the difficulties inventors have to contend with, but English railways in Africa would be no more suitable to that market than the proverbial cargo of warming-pans which we shipped to Jamaica. Messrs. Fox, Walker, and Co. unfortunately failed, and I have only just succeeded in obtaining the guarantee from the Yorkshire Engine Company, that they will construct a train which shall weigh 200 tons, and travel at the rate of 12 miles in an hour up an incline of 1 in 20. Mr. Rapier's 18 cwt. engine could only draw its own weight up 1 in 20, and if he adopted detours, and consequently heavier trains, although the cost of fuel requisite to overcome the ascent would be almost identical in each case, yet the extra length would perhaps double the total outlay, and in reality make the cost per mile between any two points, A and B, equal to a first-class railway; yet the estimated price per mile would be attractively low, and the real cost left to be found out in the future."

NINETEENTH ORDINARY MEETING.

Wednesday, April 30th, 1879; Prof. Henry E. Roscoe, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Ancketil, Maxwell, Warwick-road, Kensington, W.
Evans, Richard, 10, Bank-square, Chepstow.
Grain, J. H., Virnew-house, Lewisham-hill, S.E.
Griffith, Acton F., 2, St. Stephen's-villas, Shepherd's-bush, W.
Iliffe, William, Hartington-street, Derby.
Inch, Robert Higgs, Town-hall, Lowestoft.
Muter, John, Ph.D., F.C.S., Winchester-house, Kennington-road, S.E.
Newsome, W., Newcastle-on-Tyne.
Nichols, George Benjamin, Handsworth, Birmingham.
Preen, Harvey, Comberton-road, Kidderminster.

The following candidates were balloted for and duly elected members of the Society:—

Goslin, S. B., The Crescent Foundry, Cripplegate, E.C.
Hellyer, S. Stevens, Torridge, St. John's-road, Brixton, S.W.
Jones, Alfred, 31, Eversfield-place, St. Leonards-on-Sea.
Lincoln, Dean of, 26, West Cromwell-road, S.W.
Moreland, John B., 4, The Paragon, Blackheath, S.E.
Parry, T. S., Castle Bar-hill, Ealing, W.
Purdey, James, 28, Devonshire-place, Portland-place, W.
Stevens, Henry, 22, Bedford-row, W.C.
Trower, Henry, 36, Gloucester-square, Hyde-park, W.
Tunbridge, William Thomas, London and North-Western Railway, Stafford.
Warner, Robert, The Crescent Foundry, Cripplegate, E.C.
Wilson, Richard, 53, Parliament-street, S.W.

The discussion Mr. Hollway's paper on "A New Process of Metallurgy," read February 12th, was resumed.

The Chairman, in calling on Mr. Hollway to open the renewed discussion, said that on the last occasion Mr. Hollway had stated the principle of his process. A portion of the evidence then brought forward was experimental, and a portion theoretical. The experimental part of his statement consisted of details of experiments carried on at Penistone, up to January last, when very large quantities of pyrites were oxidised in a large Bessemer converter, proving that the heat evolved by the combustion of a portion of the sulphides was sufficient to fuse and keep in a molten state the whole of the solid matter, which amounted to many tons, added from time to time. The question of the quantity of sulphur thus burnt was one which Mr. Hollway had not determined exactly experimentally, although he had ascertained that the air issuing from the mouth of the converter was free from oxygen, showing that sulphur was present in the uncombined condition. He also brought forward other evidence, viz., the fact that a bar of wrought iron was rapidly melted in the gases issuing from the converter at a temperature which, measured by a Siemens pyrometer, was much below that needed for the fusing of wrought iron; the fusion being caused by the union of the sulphur present in the state of vapour, with the iron, so as to form sulphide of iron, which rapidly fused. Since then, Mr. Hollway had made experiments on the possibility of collecting sulphur in quantity, and the points for discussion now were, the question of the lining which he proposed to employ; in the second place, the question how far it was proved practically possible to carry this oxidation of the sulphides on in a continuous fashion; thirdly, there was the important question of the copper contained in the regulus. He would, therefore, call on Mr. Hollway to state the results of his recent experiments on these points.

Mr. John Hollway said—Two and a half months have now elapsed since I had the privilege of bringing my process for the metallurgical treatment of oxidisable minerals under your kind consideration. I then endeavoured to point out to you that the great principle upon which the process depended is the burning of mineral sulphides, notably that of iron, in such a manner, that it is possible, by the aid of the high temperature thus obtained, to fuse, decompose, and flux the substances present in the molten bath, thereby producing a slag containing the non-valuable, and a regulus containing the valuable, constituents of the said ores, together with metalliferous sublimates and crude sulphur. The magnitude of the operation, and the difficulties which surround experimental work of this nature, render somewhat tedious investigations undertaken without the advantages of specially constructed plant. After abandoning the use of Bessemer plant, which, with its costly hydraulic gear, has been a serious obstacle to some practical minds—although it served admirably to illustrate the first principles of the process—it was necessary to construct or modify a furnace in such a manner that a current of air could be forced through molten material lying on its hearth. A spiegel-melting cupola was the first furnace used in these experiments. It was fitted with tuyère boxes on each side at the bottom; three Bessemer tuyères, of 13 holes each, having a diameter of $\frac{5}{16}$-in., were used to introduce the air current into the molten sulphides. At the back of the cupola a fore-part was built of fire brick 4 ft. high. This fore-part was connected with the cupola by an aperture in the side of the latter about 20 in. high, in order that molten material undergoing oxidation on the cupola hearth might freely communicate with a quiescent hearth,

where it was hoped a separation of slag from regulus would take place. The slag produced had to rise up to the top of the fore part, leaving the furnace at the upper slag hole in a continuous stream. The regulus was to be tapped out of the fore-part. The cupola was connected by flues with two condensing cupolas, to retain the sublimates, but much sulphur burnt at the top and slag tap-hole of the blowing cupola. An experiment was made with this apparatus on the night of March 27th. The furnace made hot with coke was charged with pyrites mixed with coke, in order to procure a molten bath of protosulphides. After one or two hours, the coke was discontinued, and pyrites was added with one-fifth of its weight of sandstone. The fusion went on rapidly. The contents of the furnace being intensely hot and liquid, the slag, rising in the fore-part as anticipated, at length began to pour from the upper slag hole, which had been left open during the operation. A long flame of burning sulphur issued from this hole, until it was stopped by the rising slag, causing considerable inconvenience. While the temperature was thus gradually rising in the cupola, the stream of slag was observed to increase suddenly, and, presently, it rose with force, partly lifting the top of the forepart. It then came over in a torrent beyond control, and flowed on to the floor of the cupola stage, where it soon cooled. Several tons of matter were thus ejected, leaving the furnace almost empty. The experiment was not continued further, as the molten bath of material had thus disappeared. The tap-hole of the forepart was then opened, and some regulus was tapped out. As the operation had not proceeded long enough to produce a concentrated regulus, the per-centage of copper was known to be low, the matt actually containing 7 per cent. Five or six tons of pyrites was used in the experiment. The slag ejected was carefully examined, and no shots of regulus could be detected by the eye in it. Assays gave 0·5 per cent. and 0·6 per cent. of copper present, which copper metallurgists inform me is very slow for a slag of the high density of that produced. It was very satisfactory to observe how readily the regulus parted from the slag under the conditions of perfect fluidity which prevailed in this experiment. The per-centage of copper which the slag retained was probably natural to any slag of such high density. A large amount of the copper present was lost in this slag. The pyrites contained 1·7 per cent. of copper, and the slag formed amounts to about 0·8 of the pyrites used; this gives a loss of ·48 per cent. out of 1·7 per cent. of copper present, or 25 per cent. That there is considerable difficulty in starting the operation will be readily understood. If the sulphides above the tuyères once get overblown, the mass is almost certain to refrigerate before oxidisable matter arrives at the hearth. If, again, pyrites is introduced too rapidly before a sufficiently high temperature has been developed in the liquid mass, the temperature of the latter is greatly reduced by the volatilisation of sulphur and the fusing of the sulphide of iron. The proper slope for the boshes, the capacity and height of the crucible, the amount of air introduced, the best fluxing materials that could be added, and what quantity of them would be conveniently fused by the heat developed by the oxidation, the rate of introducing the charge—these were all unknown data, the correct mutual relations of which determine the success of the operation. A larger cupola was next fitted with a tuyère hearth, the tuyères being set in a horizontal iron plate. This furnace was fitted with a self-closing hopper, and was connected by means of flues to three other cupolas to condense the volatilised sulphur and sublimates. Spray jets of water were arranged in these cupolas; the water was finally run off into a tank. A forepart was again built similar to the last, but somewhat higher. On the evening of the 8th of April, the furnace was heated as before, and after two or three tons of pyrites had been charged, the operation was continued without the use of carbonaceous fuel. For three hours pyrites and sandstone were continually charged into the furnace; a great flame, eight or ten feet long, of incandescent vapour burnt at the upper slag hole, causing a considerable loss of sulphur. The pyrites was put into the furnace at the rate of three tons per hour; in the last hour rather more than this quantity was introduced. The pressure of blast was from 10 to 15 lbs. per square inch. At last the slag reached the upper tap hole of the forepart very hot and liquid, and poured in a thin stream on to the ground below. The flow of molten matter rapidly increased; in a few moments the stream was a foot in diameter. It was universally agreed by those present that this slag was far above the temperature at which the operation could be carried on, and that a considerable amount of earthy fluxes would easily have been fused if present. The flow of slag now suddenly became violent, lifting the cover of the forepart, it came over in a torrent, and three or four tons of liquid matter were ejected in the course of a minute. The cupola thus nearly emptied itself, and the operation was at an end. Only three minutes elapsed between the time that the slag began to flow rapidly and the final eruption. During the experiment fumes of sulphur vapour were forced through the brickwork of the first flue, leading from the blowing cupola to the the first condensing cupola. The gas in it must have been under considerable pressure; the heavy iron lid of the latter cupola was lifted by the pressure in it. Much steam was here generated by the evaporation of the water used to condense the sulphur; at the lower exit of this cupola sulphur was found, which had evidently undergone fusion, showing that the temperature had been above 115° C. When, the next morning, the first condensing cupola was opened, a large heap of crude sulphur was found lying on the floor, and the sides were thickly coated with it. The quantity collected was 20 cwt., besides some which had been deposited from the water in the tanks. This, it was evident, could only be a fraction of that obtainable by the use of more perfect means of condensation, and by preventing the escape of incandescent vapour from the tap holes and connections of the blast furnace. The slag produced contained, as before, 0·5 per cent. of copper. As the object of this experiment was mainly to show qualitatively that large quantities of sulphur could be collected, no attempt had been made to introduce other fluxing materials than the silica necessary to take up the protoxide of iron formed. The regulus produced contained 11 per cent. of copper. The cause of the eruption in both experiments has been a subject of much conjecture. It is certain that the molten matter lying over the tuyères in the cupola was displaced by an accumulation of gas above its surface, which could not find free exit through the channels prepared for it. As has been already noticed, there was undoubtedly a considerable pressure exerted in the second cupola, and along the flue leading to it. The accumulation of sulphur upon the floor of the second cupola must have impeded the free passage of the gas, which had blown it aside to secure itself an outlet. Large volumes of steam were produced in the cupola, but, on the other hand, the volume of the heated gases was greatly diminished by the fall of temperature they here experienced. Mr. J. F. Allen ascribes the accident to three principal causes; first, that the charge boiled and spurted so that it partially closed the flue leading to the second cupola; certainly some slag was found in this flue, which had been thrown up from the bath, but not enough to contract the size of the exit very materially; second, the sulphur found in the second cupola, which nearly closed the flue leading to it; and third, the pressure of hot gas and steam. When the cupola was opened, unfused matter was found lying near the hearth, mostly roasted pyrites. This principally consisted of the charge that had been added after the eruption of slag had taken place, for the heat was then insufficient to fuse solid material.

It would, probably, be advantageous to introduce the pyrites into the furnace with a flux, which contained in itself sufficient basic material to make a fusible silicate with which the protosulphide undergoing oxidation would readily mix, so that the particles of protoxide of iron formed might be brought into more perfect contact with the silica with which it must ultimately combine; under other circumstances the sandstone or siliceous rock added must remain solid until silicate of iron is formed, which must take an appreciable time. This solid material lying near the surface of the protosulphides must necessarily tend to produce a scaffold, particularly if the surface is chilled by the too rapid addition of raw pyrites. The lining of gannister was not materially injured by the experiment. As seven or eight tons of slag was produced, two and a half tons of silica were required to saturate the oxide of iron formed, and nearly this quantity was introduced with the charge. The hot gases escaping in the experiments described were not utilised to heat the charge introduced, which consequently arrived at the lower part of the furnace in the cold state; but I think this will not be found difficult to effect in a furnace of proper construction. Three experiments have since been made with the same cupola, two of which have not given the results anticipated, on account of the difficulty of getting a bath of molten sulphide, with which to start the operation; this was due to accidental circumstances. The mass set in the hearth before the coke was burnt away; this coke, lying in contact with pyrites at a red heat, would give rise to much bisulphide of carbon, thus decreasing the temperature of the mass. The coke, also, being mostly at the top of the molten slag and sulphides, which had collected over the tuyères, would not itself burn until free oxygen passed through the liquid below it. These difficulties can be avoided by starting the operation with a supply of molten sulphides from an ordinary cupola. The third experiment, which was proceeding favourably, came to a premature end by the escape of the molten matt from the cupola, owing to the lifting of the Bessemer bottom, by the generation of steam from the partially-dried gannister rammed round the tuyères. These experiments were delayed by the Easter holidays, and only terminated at 4 a.m. to-day. They suffered in many ways from the haste with which the preparations were made, arising from a desire to place the results before this meeting. I am satisfied, however, in having obtained free sulphur and a slag, containing only ·04 per cent. of copper; and as our chairman, and others here to-night, assisted at previous experiments, I think they will endorse my statement, that the rapid oxidation of protosulphide of iron will produce sufficient heat to fuse 6 cwt. of incombustible material to each ton of pyrites operated on, which is the quantity of silica and bases necessary to produce a slag of the same composition as the sample on the table, which contains less than ·1 per cent. of copper; its specific gravity is 3·6. I wish to offer my best thanks to the managing directors of John Brown and Co. for the facilities they have kindly afforded me in making these experiments, and also to their managers, for their most valuable assistance.

The Chairman said there was a gentleman present whose name was well known in connection with linings used for metallurgical processes. They had all heard of his labour in the Cleveland district, and how, by the use of lime linings for Bessemer converters, it had been found possible to obtain steel from iron which contained phosphorus. He would, therefore, call on Mr. Thomas to give his opinion as to the advantage or disadvantage of his lining for this process, or whether he thought it would be necessary to employ a basic lining.

Mr. Thomas said he had had some experience with lime linings and with siliceous linings for converters, and did not consider the former to be suitable linings for these experiments. It might stand very well for a time, but, on the whole, silicious linings, under proper conditions, would stand better. He thought the best lining for this process would be ordinary silicate brick lining. The Dowlais converters were now lined with silica bricks, which were found to stand much better, and to afford greater facilities for repair. Therefore, notwithstanding any partiality he might himself entertain for lime linings, he thought silica was the best for these experiments, and that in face of all the obstacles which might have to be encountered, they would be found to stand very well.

Mr. Arthur Cooper, manager of the Bessemer works of Messrs. Brown, Bailey, and Dixon, had had some experience with gannister linings for Bessemer converters, and had found it a very simple form of lining, and that any attacks upon it by the oxides of iron were easily repaired. He had had no experience, beyond Mr. Hollway's few experiments, with the material in question, but he could certainly support what Mr. Thomas had said, and thought that by the addition of a sufficient quantity of silica to the pyrites intended to be treated, the gannister lining would answer exceedingly well.

The Chairman invited further remarks on the linings, as the economical working of the process depended largely upon whether they would have to be frequently renewed.

Mr. French said as far as he had had opportunities of judging, the siliceous lining had given varying results; but even if the material should fail in some respects, there was no risk of the lining disappearing so rapidly as to create an objection to the process. Even if it should fail, there were other modes of dealing with the linings, such as having a minute water spray in quantity only sufficient to trickle over the walls. In that way the process could be continued, not only for days, but for weeks. Again, with regard to the hearth, which had hitherto been made of rammed gannister, if that should be found to become rapidly corroded, a very good mixture for use in smelting copper would be a compound of sifted coke-dust and fire-clay sufficiently damped. Two layers of it, one about eight inches and the other about 12 inches deep, rammed well down and allowed sufficient time to dry, would resist for a very long period the action of the copper regulus at a very high temperature. In his experience, one furnace had gone five weeks before being stopped, and the hearth was found to be entire at the end of fifteen weeks. Peroxide of iron was also found present, and there appeared to be from 40 to 50 per cent. of copper regulus, though when tested there was found to be only from 14 to 17 per cent. of raw ore. He had found that hearths of that description lasted very well indeed. Of course, in this way the carbon prevented the oxidised iron from attacking the clay. He had also had firebricks made of two parts of clay to one of coke-dust, but not with such good results. The blast had more action upon the bricks than the regulus had upon this mixture at the bottom of the furnace.

The Chairman requested Mr. Hollway to explain the experiments recently made in Sheffield, for the purpose of proving that a continuous working of the process was possible, and whether they had shown that the sulphur could be collected in large quantities.

Mr. Hollway read the portion of his paper referring to the matter, and explained the drawings of the four cupolas placed at his disposal by Messrs. John Brown and Company.

The Chairman remarked that Mr. Hollway had not stated the exact quantity of sulphur to be obtained from, say, a ton of pyrites; whether one, or more than one, atom of sulphur for every molecule of pyrites could be obtained?

Mr. Hollway said the experiment was not quantitative, but there was abundant evidence to show that

sulphur was evolved, and could be collected in large quantities.

The Chairman invited remarks from Mr. France, the manager of Messrs. Chance's works at Birmingham, to which some of the sulphur collected by Mr. Hollway had been sent to be refined.

Mr. France had received many hundredweights of the raw material from Sheffield, and found that it contained, by the refining analysis, 47 per cent. of sulphur, 24 per cent. of siliceous materials, and 28 per cent. of iron, reckoned as oxide of iron. It also contained about 1 per cent. of arsenic, and an appreciable quantity of copper, lead, and zinc, the quantities of which were not determined, for want of time. The black material was first subjected to distillation as practised in Sicily; the material was placed in closed iron retorts and distilled into brick chambers. Sulphur was rapidly evolved, and was collected and compressed in the form of a brick. He succeeded in getting rid of the arsenic to a certain extent, but could not quite free the sulphur from it. In his opinion, the sulphur itself would never be available as pure sulphur, and would not be a marketable article as free from arsenic, of which it would still contain a very appreciable quantity. The material itself, however, burned with the greatest freedom, and the whole of the sulphur, down to 1 per cent., was burned out very rapidly, but he thought the material should be sold as collected. From the experiments at Sheffield, a much richer raw material to burn than the copper pyrites, now so largely used, could, with more suitable means, be recovered, and one which would find a ready sale among acid makers. He produced a small specimen of the sulphur obtained in the fractional distillation, and explained that the skin on the top of it consisted almost entirely of sulphide of arsenic, the under part being sulphur, but not sufficiently free from arsenic to be sold as pure sulphur.

Mr. Allen, of Sheffield, said that what had been already done was satisfactory evidence that a large proportion of sulphur in a free state was obtainable by the process, even when worked under very unfavourable conditions. On the last occasion, an eminent metallurgist present refused to believe that it could be so obtained, and another gentleman asked whether a single atom of sulphur had ever been collected, though it was a matter of discussion whether he meant a single particle or an atom of sulphur in a chemical sense. With respect to the actual production of sulphur, he had seen it obtained, and it was, in fact, the enormous heap of black sulphurous material produced at the bottom of the cupola which had caused the accident referred to by Mr. Hollway. Of course such an accident as that would spoil any experiment, but when they remembered that the pyrites was melted down by means of the coke, and that it was only when the coke had burnt away, that the top of the cupola was closed and the sulphur collected, they could see that nothing like a quantitative result was possible. But even by that rough experiment 40 or 50 per cent. of free sulphur had been obtained, the rest being siliceous iron; and the material could be entirely separated if some proper condensing apparatus were interpolated between the actual apparatus and the chambers for collecting the sulphur, so that in practice they might expect to get a far greater quantity. It was also an interesting fact that about one-third of its weight was extractable by bisulphide of carbon, because it was well known that plastic sulphur was not soluble in bisulphide of carbon, but gradually changed back to the ordinary modification, so that, by obtaining a solution of it in bisulphide of carbon, it could be effectually separated from arsenic or any other impurity. The lead in it was only one per cent., which was not a very large amount. As to the quantity of the sulphur obtainable, they must not try to "kill the goose which lays the golden eggs." A good deal of the heat was obtained from the combustion of the sulphur, and in practice, an equal amount of heat was obtained from its combustion as by the combustion of the iron. Of course it was evident from that, that the more sulphur distilled off the less amount of heat would be obtained, so that they could not expect to go too far, though it was a matter of scientific interest whether the iron was not more readily oxidised than the sulphur. Unfortunately, the apparatus at their disposal did not allow any quantitative experiments to be made, but it had certainly been shown that a large quantity of sulphur was obtainable. In fact, the ore could be "cooked in its own grease," and that was a very satisfactory state of things. The experiment went on for several hours after all the coke had been burned away, and it at last came to a premature conclusion, because the mass of sulphur choked up the gas outlet, and caused it to blow out the liquid contents of the converter.

Mr. Cooper had been present on the 8th of April, when the plant shown on the drawings was employed, and was much struck with the great amount of heat developed. Although he had formerly been of opinion that it would not be practicable to carry out the process continuously, he had rather altered his views on the matter, and now thought that, with properly constructed plant, and after the difficulty of charging the apparatus so that the demand should be equal to the supply, and the supply to the demand, had been overcome in practice, satisfactory results would follow. Ten tons of pyrites were treated on that occasion, and if the experiment had not come to an end by the emptying of the hearth, from the causes explained by Mr. Hollway, he did not see why it should not have been carried on to a very much greater extent. Upon that point he would remark that the lifting of the slag into the culvert, thereby narrowing the orifice, was not so remarkable, because, in the ordinary iron cupolas, where the distance from the tuyères to the charging hole was not greater than that from the tuyères to the mouth of the culvert, as in this case, he had seen the slag thrown out of the hole with much less pressure than had been employed in that experiment, namely $4\frac{1}{2}$ lbs. to 5 lbs. a blast. This could be remedied by some arrangement for drawing out the sulphurous formation, and these difficulties might be satisfactorily overcome. The difficulty of getting a bath to start with, might be very easily overcome by melting a sufficient charge to form an initial bath in the adjoining cupola, and then running it into the furnace. With reference to the three last experiments which Mr. Hollway had referred to, he was of opinion that the object was to a very great extent gained, the proportion of copper in the slags showing ·04 and ·19. The first experiment had proved conclusively, as Mr. Allen had stated, that the sulphur could be collected in a free state. Although an amount of ingenuity had been displayed by Mr. Hollway in the adaptation of the apparatus to his process, it must appear to all who had seen it to be of a very rude description; but when they remembered the numerous accidents which had taken place in the working of the Bessemer process after so many years' experience with special machinery adapted for it, they would admit that Mr. Hollway had good reason to congratulate himself on the results of the experiments made with his extemporised apparatus.

Mr. Daniel (from Messrs. Fowler, Leeds), said Mr. Hollway had asked him to estimate the cost of the plant required to treat about 12,000 tons of pyrites per annum by this process. He had simply gone into the question of the blowing engines necessary, and the quantity of coal they would consume. From the experiments so far made, however, he thought that the plant was still in a state which made it impossible to estimate the cost of it, as it was not yet known what the plant actually would be. But to treat 12,000 tons of pyrites per annum, taking 1·6 tons of air per ton of pyrites, would require a blowing engine with a cylinder of 25 inches diameter,

and the total cost of that engine, with the necessary boilers, would be about £900. The consumption of fuel would be about 850 tons, to supply steam for producing the amount of air necessary for the purpose.

The Chairman supposed that Mr. Daniel had given his estimate as an addition to that which had been made by Mr. Howson on the last occasion, giving the particulars of the cost of plant for working on a very considerable scale, the figures of which appeared in the paper.

Mr. Daniel explained that his estimate did not include any of the extra plant which Mr. Howson specified in his estimate, because that would not be necessary for working on a small scale.

Mr. Hollway said the question was what would be the consumption of air, looking at the quantity of pyrites to be treated. Mr. Howson's estimate included complete copper works on a large scale, whereas Mr. Daniels' simply included apparatus for converting copper ore into regulus in smaller quantities.

Mr. Bell, of Sheffield, said that at the last meeting, prior to the experiments, he had noticed that several gentlemen threw doubt upon the possibility of getting sulphur from iron pyrites. They all knew that it was possible, because they had seen it done long before Mr. Hollway introduced his process, in the roasting of iron pyrites in Germany, in Hungary, and in many other countries, where iron pyrites was roasted in open piles in quantities as large as 600 tons at a time, whereby the extra atom of sulphur distilled off and the sulphur was collected by making wells in the piles. The sulphur was then ladled out into moulds, and the ordinary rolls of sulphur were obtained. There was an old story, which appeared in *Punch*, of an inventor who made a stove that would save 50 per cent. in the coal required, and an Irishman proposing to buy two of the stoves so that he might save the whole of his fuel; he must confess that he had himself conducted an experiment upon that principle. He had thought that possibly the heat generated in the zone of combustion might cause the whole of the sulphur to distil off into the chambers when the iron came down into the zone of fusion, and of course there would be only the iron left, and the whole of the oxygen would have combined with the whole of the sulphur. Consequently he tried to imitate Mr. Hollway's process as near as he could, by using a combustion tube in an ordinary furnace in connection with an aspirator. In one end he placed pyrites, and in the other charcoal. Heat enough was then applied to the charcoal to form carbonic oxide and carbonic acid, not exactly in the same conditions as they would be obtained by Mr. Hollway's process, but under parallel conditions, inasmuch as there would be a reducing atmosphere. Having obtained that, he applied it to the pyrites so as to raise the temperature, and found that the extra atom of the sulphur, indeed, pretty well the whole of it, distilled off, not only so as to nearly fill up his tube, but so that he obtained a large quantity of free sulphur.

Mr. Galbraith thought one part of the subject had not been noticed. It was well known that iron pyrites consisted of one atom of iron and two atoms of sulphur; and that by heating it in a closed furnace, or in a closed vessel, as described by Mr. Bell, they would get one atom of the sulphur driven off as sulphur. That amounted to something like 25 per cent. of the pyrites. There was no doubt that that amount could be got as sulphur; but the astonishing element in Mr. Hollway's process was, that on heating the iron pyrites, with one atom of the sulphur driven out, and one atom left behind, when that was put into the converter, as was done in the experiments, and the air blown through it, it was found that at the mouth of the converter there was an enormous quantity of sulphur burning; and of course, if it were not for the air, that would have deposited as sublimated sulphur. There appeared to be evidence that protosulphide of iron did exist, not at low, but at high temperatures. In Mr. Hollway's original paper, the figures given of the regulus were that it contained 57 per cent. of iron, and of copper, 15·85, while the sulphur was 21·96, and the silica only 2 per cent. Those reguli almost theoretically corresponded with the formulæ Cu_2 S, Fe_2 S. Thus, lower sulphide of iron must have existed at the higher temperatures. The point he wished to draw attention to was, that with regard to this lower sulphide of iron, many experiments had been made to form it, but it was found that it did not exist at low temperatures. Probably, however, it did exist, but it formed proto-sulphide of iron and metallic iron corresponding to the formulæ Cu_2 S, Fe S, and Fe. That was a very important point with regard to the extraction of sulphur, because otherwise more than the first atom could not possibly be got. It had also a very important bearing upon the metallurgy of nickel and copper.

Mr. Greenway said, with regard to the residue after distillation of the first portion of the sulphur, that the sulphide of iron remained behind the sulphuric acid, going off as sulphuretted hydrogen, showing that one atom of the sulphur had gone off, leaving only sulphide of iron behind it. There was no doubt, therefore, that it was possible to recover nearly the whole of the first atom of sulphur.

Mr. Bell had forgotton to mention that he had sulphide of iron left behind also, and that he had added hydrochloric acid and got off sulphuretted hydrogen.

Mr. Stead, with reference to the sulphur question, said there was no doubt, that since the last meeting, Mr. Hollway had made a step in the right direction. Certainly, a considerable quantity of sulphur had been obtained; but it was ugly-looking, black stuff, and not at all like sulphur, and any person would say that it was not without putting it to a trial. It had been suggested that this material, containing only 47 per cent. of sulphur, could be advantageously imported from Spain without refinement; but there would be no advantage in doing that, because it was questionable whether any cost would be saved to the sulphuric acid manufacturer, as the amount of sulphur in the original pyrites was nearly the same. He thought it would be an easy matter to distil that sulphur without any extra cost of fuel. If the hot gases from the Bessemer furnace were taken into a stove containing a series of retorts, similar to those in a gas-house, taking the gas in at one side and passing it out at the other, the crude sulphur might be easily distilled off by the excess of heat from the combustion of the pyrites in the converter. That would be a decided advantage, and there would be no difficulty in effecting it, as the gases would be cooled by the distillation of the sulphur, and there would be less cooling and less condensing required in the next chamber. If that suggestion were adopted, it would be another step gained. Since the last meeting also, the slag had been materially improved by the larger quantity of the copper having been got rid of, which had been effected by the addition of lime. If it should eventually be proved that the addition of a considerable quantity of lime to a copper slag precipitated the copper from it, a discovery would have been made of the utmost importance to copper smelters.

The Chairman then invited discussion on the subject of the copper in the regulus produced by the process, and asked for a preliminary statement from Mr. Hollway on the point.

Mr. Hollway said that Mr. Arnold heated some of the slag in a crucible at a high temperature, allowed it to remain for a long time, and found that no regulus was separated; which clearly indicated that the regulus was not entangled in it, unless it were so minutely that it could not be separated by heat. In the experiments at Sheffield, they obtained a slag containing only ·04

per cent. of copper, and he held that the process could easily be worked so as to leave no more than ·01 or ·02 per cent. of copper in the slag, by making the sp. gr. somewhat lighter, though, perhaps, there was also a chemical question connected with it, viz., the presence of lime or similar bases in the slag.

Mr. Collins (Truro) said his experience had been more in the way of assaying than smelting, but he was somewhat familiar with the methods employed. With reference to the sulphur question, he thought the best way of treating the crude sulphur would be, not to dissolve one-third of it with bisulphide of carbon, but to treat it in a bath of chloride of calcium. He believed the process had been patented, and was in use in Sicily at the present time. It should be made of a proper density, to melt and float out the sulphur and leave the sulphide of arsenic at the bottom, the sulphur would then be perfectly free from arsenic. But this sulphur was only one of five products which Mr. Hollway got at one operation. On the first, the sulphurous anhydride, he had nothing to say; the second was the sulphur; then he had the slag; the mixed slag and regulus, and lastly the regulus. As to the slag, the specimen on the table was by far the most satisfactory which had been produced, but the experiments altogether were not quite satisfactory, inasmuch as this slag, poor in copper, was not accompanied by a regulus rich in copper. But going back to July, 1878, there was then a series of experiments, when slags were produced of a specific gravity of 4·11 and a regulus of an average specific gravity of 4·96; these experiments were on a very fair scale, and it seemed to him that, having regard to the slag and the regulus, they were by far the best made yet. The difference in the specific gravity of the slag and regulus being so small, led to this fifth product, the mixed regulus and slag, which should be got rid of altogether. That seemed now to have been accomplished by the very obvious method of adding lime; the slag being thus lightened, the regulus subsided readily. He took with him from Sheffield some specimens of this mixed slag and regulus, had them cut, and examined them under the microscope, when he found in them a great many shots of perfect regulus; but if pounded up, and these were separated, the specific gravity was as nearly as possible what was shown in the table, 3·7. It was objected last time that, if lime were used, or some similar material, to lighten the slag, it would be a waste product, not fit to be treated as an ore of iron; but since then, Mr. Blair, who made the objection, had withdrawn it. Coming to the regulus itself, he found it contained something like 60 per cent. of copper, over 12 of iron, and 22 of sulphur, and it was impossible to look at these figures without seeing how nearly they approached to what copper smelters called "blue metal," or fine metal. He had a number of analyses of this material, and one, which he thought a fair average, was this:—72 or 73 per cent. of copper; iron, about 6·5; and sulphur, about 20. Mr. Hollway's regulus contained about 63 of copper, 13 of iron, and 22 of sulphur. Of course the analyses were not identical, but they were sufficiently near to satisfy him that Mr. Hollway, by his one process, had effected a very marvellous result, for this blue metal was only obtained in the Welsh copper smelting process from sulphurous ores by from four to six distinct roastings and smeltings, at great cost of fuel and labour. Mr. Hollway did it in one vessel, with very little labour, and with no fuel at all. If he could do nothing more than that, the success of his process was assured.

The Chairman asked if Mr. Collins could give the particulars of the process for obtaining the sulphur, which, he said, was practised in Sicily. He was not aware that the Sicilian sulphur contained arsenic in sufficient quantity to render such a process necessary.

Mr. Collins said the process was carried out at the present time by Mr. Peter Le Neve Foster, son of the late Secretary of the Society. It was not used to get rid of arsenic, but because the sulphur was mixed up with a great deal of rock, and it was a convenient mode of separating it without loss.

Mr. Terrell (Swansea) said he should speak from one special point of view, viz., how far was this process adapted for treating copper ores; or rather, how far might the ordinary Welsh method of smelting copper be replaced by a new process based on Mr. Hollway's invention. He believed this process could be applied with advantage in conjunction with the smelting of ordinary sulphur copper ores, for the following reasons: —Pyrites and protosulphide of iron were both intimately connected with copper smelting as now conducted, but the sulphur was nearly always wasted. It was neither used to produce heat by its oxidation, nor was the product of its combination used for making sulphuric acid to any great extent. The reason why the heat produced was not available, was because the oxidation was so slow that there was not a sufficient amount of calorific intensity produced to do any work; whereas in this process he was satisfied, from what he saw at Sheffield, that more than enough heat was produced, not only to melt the slag immediately connected with the sulphides, but also to melt certain quantities of other ores such as were usually used contained material which, together with the silicate of iron, would form a still more fusible mixture than that alone, and at the same time form a slag of less specific gravity. He referred to such gangues as silicate of magnesia, &c. He was satisfied that the process could be carried on continuously, so long as the lining of the furnace would stand, that it could be carried on rapidly, and that much larger quantities of ore could be charged than in an ordinary reverberatory furnace. Again, in various parts of the world where fuel was scarce, ores poor in copper and rich in sulphur could be concentrated into a regulus which might profitably be imported into this country. The very rich pyritous ores containing little copper would serve as fuel, which would be sufficient to melt certain quantities of carbonate ores and other oxidised ores of copper, and so get more copper into the regulus, without additional blowing through the regulus itself to enrich it. He could say little about the separation of the sulphur, but whatever could be done in that way would add to the value of the process. He made his estimate of it simply on the basis of the Welsh method of copper smelting, wherein neither the excess of sulphur of the iron pyrites nor the sulphur dioxide produced were utilised, but were allowed to poison the atmosphere and kill vegetation; he would not say anything about human life, for he himself had certainly not suffered from it. Any present idea as to the form of the apparatus would probably have to be modified by experience; but if they once had the principle correct, there was plenty of mechanical skill in the country to devise the requisite apparatus. He must say he did not quite see the analogy between the per-centages Mr. Collins had quoted.

Mr. Collins having repeated the figures before stated, said he thought the invention would be better left in Mr. Hollway's hands, rather than handed over to the copper smelters, as suggested by Mr. Terrell. Great improvements generally came from outside.

Mr. Hollway remarked that he had already received assistance from the copper trade, and he trusted he should have further help hereafter.

Mr. Heywood (Cardiff) thought it must be admitted that Mr. Hollway's experiments had proved to a certain extent a success, and great credit was due to him for it. With reference to the sulphur, he was present at the experiments carried on at the Atlas Works, and he understood that some of the sulphur product was roughly analysed at the works, and found to contain only 4 or 5 per cent. of residuum. It would, therefore, be impossible for that sample to contain the

enormous quantity of from 30 to 40 per cent. of iron, silica and zinc, which had been represented; and if any portion of sulphur did really contain 5 per cent. residuum, it would be quite impossible to obtain a larger quantity, in fact, the whole of it contained no more than 5 per cent. As Mr. Allen had remarked, sand would naturally occur from the apparatus employed, the pyrites would disintegrate to some extent, and the coke would be blown over, and therefore there would be more residuum than would be obtained in actual practice. In Mr. Hollway's former paper, there were analyses of a slag, giving the average of the copper at ·15, and no doubt it was of great importance that slag should contain no greater percentage, at any rate than that produced by the Swansea method. If the present slag was one which could be relied upon, in his opinion the success of the experiment had been thoroughly shown.

Mr. Clements suggested that this process might be adopted in Spain for the treatment of the Rio Tinto ore, and the regulus imported into this country, instead of the pyrites. The sulphur could also be used there for making sulphuric acid, which, if there were railway communication, might be advantageously used in the treatment of the phosphorite deposits of Estramadura, thus producing superphosphate, which was so valuable in agriculture.

The Chairman said Mr. Hollway had received a letter from a gentleman at the Salt Lake City, the manager of a mining and smelting company there, where it appeared that the fame of this process had already spread. In that district there were large deposits of pyrites, and being sparsely populated, this process could easily be adopted, and the sulphur need not be condensed. He understood that Mr. Longmaid, who was present, had been in the district himself, and could give some information.

Mr. Longmaid said he was not in any way connected with Mr. Hollway, but he had been to see the experiments at the instance of Mr. Holden, of Utah, with a view of introducing the process into America. He was connected with the largest silver lead mining property in Utah, and beneath the oxidised ores which lay near the surface, there were vast deposits of iron pyrites, containing besides silver and gold, many of them contained from 8 to 20 ounces of silver and $\frac{1}{4}$ to $\frac{1}{2}$ an ounce of gold, mixed also with a certain percentage of lead and galena. They had been to some extent roasted to volatilise the sulphur and then smelted with coke as a flux with lead ores. But the process was very expensive, owing to the cost of labour and fuel, and therefore the great bulk of the pyrites would not pay for the operation. He had been to Sheffield and seen the experiments, and was perfectly surprised to find the intense heat evolved by the combustion of the pyrites. He must say that in his opinion no heat whatever was evolved from the volatilisation of sulphur. He thought the metallic iron was the source of the heat, and that the combustion was so intense that the sulphur could not combine with the oxygen in the presence of iron at that temperature, but he scarcely liked to hazard that opinion among so many scientific men. It was not only in Utah that there were such vast deposits of pyrites. It also occurred in all the western States, especially Colorado. In Nevada there were large quantities, and some mines produced ore of very high quality, but which could not be used at all on account of the expense of fuel. By this process he believed these ores could be treated. With reference to the linings, he thought the difficulty might be easily got over where aluminous or siliceous linings were used, by covering the furnaces on the exterior with water jackets, so as to keep the linings always at a temperature below the point of combination of silica and iron. They would be further preserved by smelting with siliceous slags instead of basic slags. On the subject of slags carrying a matt, his experience in lead smelting showed that a very large proportion of sulphide of iron and copper would be carried into the slag by making very basic slags; in fact, in lead smelting, with from 8 to 10 per cent. of sulphur, they would carry the whole of it into the slag with the quantity of iron and zinc necessary to form sulphides. It was a mere matter of calculation to produce slags which would not carry any matt. In conclusion, he had only to say, that in about two weeks, if he could make arrangements with Mr. Hollway, he intended to return to Utah, to put the process into practical operation.

The Chairman said the last announcement was a most practical one. The people of Utah were very energetic; and no doubt they would soon hear of the process being at work. There were large deposits of pyrites, not only in the United States, but in other parts of North America, and he believed Mr. Thompson could speak as to the deposits in Canada.

Mr. Thompson said he could claim neither theoretical nor practical knowledge of metallurgy, but he left America six weeks ago for the purpose of making arrangements for carrying out this process. Without detracting from Mr. Hollway, to whom all honour was due, but to show the value of this idea, he might mention that it was one which the necessities of the time had been bringing to the surface. Mr. Eustiss, of Boston, had commenced experimenting on the process about the same time as Mr. Hollway, and had been going on with it independently. Those experiments all tended to show the success of the idea and the value of it. There were in Canada certain large deposits of iron pyrites, carrying a comparatively small quantity of copper, very much resembling the Spanish deposits, and he was here for the purpose of making arrangements for the control of such works. His associates at home were at work on the ground making preparations for trying the process, and in another month or two he hoped to have a shipment of regulus on its way to Swansea, made by what they might call the Hollway process.

Mr. Galbraith wished to refer again for one moment to the sulphur question. Mr. Heywood said he had received a sample from Sheffield containing 4 per cent. of residue, and he had no doubt that such could be obtained, though he did not know that it had been yet. They found some samples contained 80 per cent. of sulphur, but the average contained 50 per cent. With regard to the slag and regulus question, the analysis placed before them shewed ·04 per cent. of copper in the slag, and in one sample he had he was much surprised to find scarcely a trace of copper, considering that the experiment came to a sudden termination. He picked up one piece himself in which there was rather more. Another piece contained ·19. The copper seemed to vary considerably, and this naturally raised the question, how did the copper exist in the slag overlying the regulus? If it existed as a silicate, and was really combined with the regulus, it would not be expected to vary so much, but if it were merely suspended throughout the slag, they could understand how it must vary, and on crushing it up fine and examining it, he had found several traces of regulus, if not of metallic copper. With regard to the separation of the regulus from the slag, it was evident that if it were allowed more time it would have a better chance of settling out. In some experiments it was allowed to flow out and cool as best it could, and there was an intermediate layer of mixed slag and regulus, so that hitherto the separation question had not had a fair chance. Another means would be to make the slag lighter, by introducing more lime. With regard to the starting of the process, it was evident you must have a molten bath to commence with, because if you had a solid mass on the tuyères you could not get the blast to work. The cupolas were heated up with coke, and gradually the pyrites was introduced; and as soon as it

got melted it lay at the bottom, and consumed all the oxygen, so that the coke over it was not burned at all. If you introduced the pyrites too rapidly, the volatilisation of the sulphur was too rapid, and would chill it, and under some circumstances, therefore, coke would not be a fuel at all. The difficulty was how to hit the mark exactly, so as to get a bath and burn the coke and keep up the heat. He did not think, however, that this difficulty would occur in working on a large scale.

Mr. Allen (Sheffield) wished to endorse what Mr. Galbraith had stated as to the variable quantity of copper in the slag; and also to mention that there had been certainly distinct specks of metallic copper in a sample of slag run from the slag hole. It was in a state of violent commotion immediately before, so that this was naturally to be expected. He thought it was quite possible to obtain such a sample of sulphur as Mr. Heywood mentioned. Mr. Collins had misunderstood him in saying that in his experiment one-third of the sulphur was dissolved out in bisulphide of carbon. He dissolved ·33 per cent. out of ·45 per cent. present.

Mr. Stead thought the separation of copper from the slags was a matter simply of arranging the composition of the slag.

Mr. Thompson said, with regard to the sulphur question, he had extracted the sulphur by a process of this kind. One atom was burned off in the shape of sulphurous acid, and then, by forcing through the heated pyrites superheated steam, the other was carried off in the shape of sulphuretted hydrogen. The gases were taken into a separate chamber and there mixed and precipitated, giving much more pure sulphur than was obtained in these experiments.

Mr. Bell said he had been in Colorado a considerable time, and he could endorse the remarks of Mr. Longmaid. There were plenty of siliceous ores there which would make an excellent flux. He went to the experiments on the 8th rather sceptical, but came away quite converted; he never saw a more liquid slag than came from the converter. He concluded that siliceous and sulphur ores could not only be mixed so as to get a good regulus, but that the furnace would even carry basic ores, of which there were many in Colorado—ores containing as much as 3,000 oz. of silver to the ton; those containing only 30 oz. were not considered worth treating, but as soon as the sulphur could be utilised, they could be treated for silver and gold. With regard to the furnace itself, he thought the misfortunes which had occurred had not been due to any fault in the principle itself, but simply to over-feeding, and he would suggest that the charging should be made automatic. Where sulphur and iron were also used as fuel, only not at a pressure, you could then have a bath of molten metal, as in the hearth furnace used for smelting lead. He would suggest also that the blast should be finely divided, like an Argand burner, which would produce more heat; and instead of using a water space to carry away and waste the superfluous heat, that the furnace should be enclosed in a jacket, in which the air to be passed into the furnace should be carried, so as to utilise the waste heat to heat the air going into the furnace.

The Chairman, in closing the discussion, said the subject had now been very well ventilated, and as far as he could see, the more it was ventilated the more satisfactory did the results appear. There had been a great number of practical men present, who had spoken from experience, and he thought they must all be convinced that at any rate for the working of certain copper ores this process would be most important. Whether the whole of the sulphur could or could not be recovered seemed to him a matter of minor importance; sulphur was not so valuable a substance as copper, and though no doubt in situations where it was advisable and necessary the sulphur could be obtained, there were many places where it would be found more economical to allow it to go into the air, and he did not see why that should not be done. In conclusion, he proposed a vote of thanks to Mr. Hollway for his extremely valuable paper.

The motion having been carried,

Mr. Hollway, in reply, expressed his great obligation to Professor Roscoe for his kindness in taking the chair, and for the great interest he had shown in the subject.

CORRESPONDENCE.

ENGLISH FRESH-WATER FISHERIES.

My remarks at the fresh-water fisheries discussion are not quite correctly given in the *Journal*. I said that within the last year or two my brother had taken five salmon in a day, with the rod, in the Wye, and that I had heard, on one occasion, of even 10 being taken in the day by an angler, in the upper part of that river. I added, also, that the Wye was fearfully polluted for several miles of its course by the sewage of the city of Hereford. As a matter of fact, the sewage injuriously effects the fisheries below Hereford for from 10 to 15 miles. J. LLOYD.

Huntington-court, Hereford,
April 30th, 1879.

NOTICES.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

PROCEEDINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at Eight o'clock:—

MAY 7.—"The Government Patent Bill." By W. LLOYD WISE, Esq., Assoc. Inst. C.E. F. J. BRAMWELL, Esq., F.R.S., will preside.

MAY 14.—"The Automatic Hydraulic Brake." By E. D. BARKER, Esq. Capt. DOUGLAS GALTON, C.B., LL.D., F.R.S., will preside.

MAY 21.—"Edison's New Telephone." By CONRAD W. COOKE, Esq. Prof. J. TYNDALL, LL.D., F.R.S., will preside.

NOTICE TO MEMBERS.

At the Ordinary Meeting of the 21st May, the usual rules for the admission of Members and their friends will be suspended. Admission will be by tickets only, and no person, whether a Member or not, will be admitted without a ticket. A sufficient number of tickets to fill the room will be issued to applicants in the order in which they apply. Each ticket will be numbered, and will admit one person, and is transferable. Not more than a single ticket can be issued to any one Member. Members requiring tickets should apply at once to the Secretary.

AFRICAN SECTION.

Tuesday Evenings, at Eight o'clock.

MAY 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By EDWARD HUTCHINSON, Esq., Lay Secretary of the Church Missionary Society. ARTHUR MILLS, Esq., M.P., will preside.

CHEMICAL SECTION.

Thursday Evenings, at Eight o'clock.

MAY 8.—"The History of Alizarine and Allied Colouring Matters, and their production from Coal Tar." By W. H. PERKIN, Esq., F.R.S.

MAY 15.—Continuation of Mr. Perkin's paper.

INDIAN SECTION.

Friday Evenings, at Eight o'clock.

MAY 2.—"The Wild Silks of India, especially Tussah." By THOMAS WARDLE, Esq. Sir P. CUNLIFFE OWEN, C.B., K.C.M.G., will preside.

MAY 23.—"The Harbour of Kurachee." By W. J. PRICE, Esq., M.I.C.E. Sir WILLIAM MEREWETHER, C.B., K.C.S.I., will preside.

CANTOR LECTURES.

Third Course: Five Lectures by W. H. PREECE, Esq., on "Recent Advances in Telegraphy."

LECTURE III.—MAY 5.

Simple telegraphy. Visual and aural signals. Telephones. Telegraphic writing.

LECTURE IV.—MAY 12.

Duplex, quadruplex, multiplex, and harmonic telegraphy.

LECTURE V.—MAY 19.

Automatic and fast-speed telegraphy.

Members can admit TWO friends to each of the Ordinary and Sectional Meetings, and ONE friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

MON......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. W. H. Preece, "Recent Advances in Telegraphy." (Lecture III.)
Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Mr. F. Street, "The Management of Heavy Land."
Royal Institution, Albemarle-street, W., 2 p.m. General Monthly Meeting.
Society of Engineers, 6, Westminster-chambers, 7½ p.m. Mr. Edward D. Barker, "Hydraulic, Continuous, and Automatic Brakes."
Royal United Service Institution, Whitehall-yard, 8½ p.m. Mr. W. H. White, "The Turning Powers of Ships."
British Architects, 9, Conduit-street, W., 8 p.m. Annual General Meeting.
Medical, 11, Chandos-street, W., 8.30 p.m. Annual Oration.
Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. Rev. S. J. Whitmee, "The Ethnology of the Pacific."

TUES.....Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.
Royal Institution, Albemarle-street, W., 3 p.m. Mr. Ernst Pauer, "Schubert, Mendelssohn, and Schumann." (Lecture III.)
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Discussion upon "Carriage-way Pavements."
Statistical, Somerset-house-terrace, Strand, W.C., 7¾ p.m. Mr. W. Neilson Hancock, "The Feasibility of Compulsory Education in Ireland."
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.
Biblical Archæology, 33, Bloomsbury-street, W.C., 8½ p.m.
Zoological, 11, Hanover-square, W., 8½ p.m. 1. The Secretary, "Additions to the Menagerie." 2. Rev. H. B. Tristram, "Description of a new species of Woodpecker, from the Island of Tyzus Sima, near Japan." 3. Mr. F. Moore, "Descriptions of new genera and species of Asiatic Lepidoptera Heterocera."
Royal Colonial (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m.

WED....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. W. Lloyd Wise, "The Government Patent Bill."
Iron and Steel Institute, at the Institution of Civil Engineers, 25, Great George-street, Westminster, S.W., 10.30 a.m. Annual Meeting. Inaugural address by the President-Elect, Mr. Edward Williams. Presentation of the Bessemer Medal for 1879, to Mr. Peter Cooper, of New York, "the father of the American Iron Trade." Discussion on the Paper read at Paris by Mr. Daniel Adamson, on "The Mechanical Properties of Iron and Mild Steel," resumed; and a Supplementary Paper by Mr. Adamson.
Entomological, 11, Chandos-street, W., 7 p.m.
Archæological Association, 32, Sackville-street, W., 8 p.m.
Obstetrical, 53, Berners-street, Oxford-street, W., 8 p.m.

THURS...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Chemical Section.) Mr. W. H. Perkin, "The History of Alizarine and Allied Colouring Matters, and their Production from Coal Tar." (Part I.)
Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. T. H. Wright, "The Music of the Harp, and National Airs of Ireland and Scotland," with illustrations.
Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "Dissociation." (Lecture II.)
Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.
Royal Historical, 11, Chandos-street, W., 8 p.m. 1. Mr. Cornelius Walford, "Early Laws and Customs in Great Britain regarding Food." Mr. Edward Christie, "The Renaissance and its Influences on English Society."
Royal Society Club, Willis's-rooms, St. James's, S.W., 6 p.m.
Iron and Steel Institute, at the Institution of Civil Engineers, 25, Great George-street, S.W., 10.30 a.m. 1. Mr. Nathaniel Barnaby, "The Use of Steel in Naval Construction." 2. Mr. H. N. Maynard, "The Use of Steel in the Construction of Bridges." 3. Mr. Sidney G. Thomas, and Mr. Percy C. Gilchrist, "The Elimination of Phosphorus in the Bessemer Converter." 4. Mr. G. J. Snelus, "The Removal of Phosphorus and Sulphur during the Bessemer and Siemens-Martin Processes of Steel Manufacture."
Mathematical, 22, Albemarle-street, W., 8 p.m. 1. Dr. Hirst, "The Complex whose Lines join Conjugate Points of Two Correlative Planes." 2. Prof. Cayley, "Note on a Geometrical Theorem Connected with the Function of an Imaginary Variable." 3. The late Prof. Clifford, "Notes on some Definite Integrals." 4. Paper by Mr. E. J. Routh.

FRI......Royal United Service Institution, Whitehall-yard, 8½ a.m. Colonel J. C. Gawler, "South Africa and its Military Aspects."
Royal Institution, Albemarle-street, W., 8 p.m., Weekly Meeting. 9 p.m., Sir John Lubbock, Bart., "The Habits of Ants."
Astronomical, Burlington-house, W., 8 p.m.
Archæological Institution, 16, New Burlington-street, W., 4 p.m.
Iron and Steel Institute, at the Institution of Civil Engineers, 25, Great George-street, S.W., 10.30 a.m. Mr. John Pattinson, "A New Volumetric Method of Determining Manganese in Manganiferous Iron Ores, Spiegelesen, Steel, &c." Mr. Edward Riley, "A Ready Means of Moulding Lime, and Making Lime or Basic Bricks and Linings for Furnace Converters, &c." 3. Mr. Edwin Pettitt, "A Practical Combination of the Bessemer and Puddling Processes." 4. M. Escalle, "The Results of Working the Godfrey-Howson Furnaces at the Works of Tamaris, Gard, France." 5. Mr. H. Louis, "The Chemistry of Puddling." 6. Prof. Barff, "A New Process for Protecting Iron and Steel against Rust."
Quekett Microscopical Club, University College, W.C., 8 p.m.
Clinical, 53, Berners-street, W., 8½ p.m.
New Shakespeare Society, University College, W.C., 8 p.m. 1. Rev. Dr. Grosart, "Shakespeare's Sonnets." 2. Mr. Edward Rose, "Shakespeare's Treatment of Women."

SAT......Royal Institution, Albemarle-street, W., 3 p.m. Mr. H. H. Statham, "The Leading Styles of Architecture Historically and Æsthetically Considered." (Lecture III.)

JOURNAL OF THE SOCIETY OF ARTS.

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FRIDAY, MAY 9, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

THE ALBERT MEDAL.

The Council of the Society of Arts attended on the 6th inst. at Marlborough-house, when his Royal Highness the Prince of Wales, as President of the Society, presented to Sir William George Armstrong, C.B., D.C.L., F.R.S., the Albert Medal, awarded to him "because of his distinction as an engineer and as a scientific man, and because, by the development of the transmission of power —hydraulically—due to his constant efforts, extending over many years, the manufactures of this country have been greatly aided, and mechanical power beneficially substituted for most laborious and injurious manual labour." The members of the Council present were :—Lord Alfred Churchill (Chairman), the Earl of Northbrook, K.C.S.I., Sir John Lubbock, Bart., M.P., F.R.S., Mr. F. A. Abel, C.B., F.R.S., Mr. G. C. T. Bartley, Dr. Birdwood, C.S.I., Mr. F. J. Bramwell, F.R.S., Mr. E. Chadwick, C.B., Mr. Hyde Clarke, Captain Douglas Galton, C.B., F.R.S., Mr. H. Reader Lack, Mr. Robert Rawlinson, C.B., Prof. Erasmus Wilson, F.R.S., Mr. J. A. Youl, C.M.G., with Mr. H. Trueman Wood (Secretary), and Mr. H. B. Wheatley (Assistant-Secretary).

CANTOR LECTURES.

The Third Lecture of the Third Course of Cantor Lectures, on "Recent Advances in Telegraphy," was delivered on Monday, the 5th inst., by Mr. W. H. Preece.

In order to illustrate the lecture, an instrument in the room was connected with one in the General Post-office, and messages were sent to and fro during the lecture.

Mr. E. A. Cowper's Writing Telegraph was also exhibited in action and explained, through the kindness of the inventor, who, with his son, was present, and after the lecture showed the working of the instrument to the audience.

The Lectures will appear in the *Journal* during the summer vacation.

EDISON'S TELEPHONE.

At the Ordinary Meeting of the 21st May, a paper will be read on "Edison's New Telephone," by Mr. Conrad W. Cooke; Professor J. Tyndall, LL.D., F.R.S., in the chair. On this occasion the usual rules for the admission of Members and their friends will be suspended. Admission will be by tickets only, and no person, whether a Member or not, will be admitted without a ticket. A sufficient number of tickets to fill the room will be issued to applicants in the order in which they apply. Each ticket will be numbered, and will admit one person, and is transferable. Not more than a single ticket can be issued to any one Member. The issue has now commenced, and Members requiring tickets should apply at once to the Secretary.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference will be held in the Rooms of the Society of Arts, on Thursday and Friday, the 15th and 16th May, 1879, on National Water Supply, Sewage, and Health, the Right Hon. JAMES STANSFELD, M.P., late President of the Local Government Board, in the chair, assisted by the members of the Executive Committee :—Lord Alfred Churchill (Chairman of Council); Sir Henry Cole, K.C.B.; Colonel Sir E. Du Cane, K.C.B.; Captain Douglas Galton, C.B., F.R.S.; Mr. F. A. Abel, C.B., F.R.S.; Mr. T. W. Keates; Dr. Voelcker, F.R.S.; Mr. W. Hawes, F.G.S.; Major-Gen. F. Cotton, R.E., C.S.I.

The Conference will meet each day at 11 a.m., and sit till 1.30, then adjourn till 2, and sit again till 5 p.m., and, if necessary, meet again at 8 p.m.

Tho procceedings will be opened at 11 on Thursday by an address from the Chairman, the Right Hon. JAMES STANSFELD, M.P. The papers and discussions will be taken under the following heads :—

1. Methods of securing a sufficient supply of pure water.
2. Evils of impurity, and consequent connexion of the question of water supply and sewage.
3. Methods of sewage, &c.

There will be an Exhibition of Mechanical and Chemical Apparatus in connexion with Water Supply, Treatment of Sewage, and Health.

The Exhibition will be open from 10 till 8 on Thursday, the 15th, and from 10 till 5 on Friday, the 16th of May.

Members have the privilege of admitting two persons, either personally or by the usual ticket, on each day the Exhibition is open.

The object of the Conference is to discuss existing information in connexion with the results of any systems already adopted in various localities, referring to the subjects of National Water Supply, Sewage, and Health; to elicit further information thereon; and gather and publish, for the benefit of the public generally, the experience gained. The introduction and discussion of untried schemes will, therefore, not be permitted. The papers accepted for the Conference will be printed and circulated at the Meetings.

PRACTICAL EXAMINATIONS IN MUSIC.

An examination for candidates residing in or near London has been arranged to be held at the House of the Society of Arts, during the week beginning June 16.

The examinations will be exclusively practical, and will take account of voice, style, ear, and reading.

Candidates in vocal music will be required—

1. To sing a solo, or to take part with another candidate in a duet, already studied. Credit will be given for the choice of the piece sung.

2. The pitch of a key-note being given, to name sounds or succession of sounds, played or sung by the examiner in that key and in the keys connected with it; *e.g.*, the dominant, subdominant, relative minor, or other.

3. To sing or solfa at sight passages selected generally from classical music.

Candidates in instrumental music will be required—

1. To play a piece already studied. Credit will be given for the choice of the piece played.

2. The pitch of a key-note being given, to name sounds, played by the examiner in succession or in combination, in that and its relative keys.

3. To play a piece or portion of a piece at sight.

The maximum of marks is 100. These will be distributed among the subjects of examination in the following proportion:—

VOCAL MUSIC.

Voice	20	per cent.
Style	20	,,
Ear	20	,,
Reading	40	,,

INSTRUMENTAL MUSIC.

Execution	20	per cent.
Style	20	,,
Ear	20	,,
Reading	40	,,

Candidates who obtain 75 marks will be entitled to a first-class certificate; and those who obtain 50 to a second. Candidates, the number of whose marks is below 30, will be entered as "not passed."

Before admission to the examination all candidates must have sent in a certificate, from a professor or other musical authority, to the effect that their qualifications are such as to afford a reasonable chance of their passing. Vocal candidates must come provided with a second copy of the solo or duet they have studied, in the established notation.

An accompanyist will attend the examination for vocal music, but candidates who prefer to do so, can bring an accompanyist with them.

Each candidate must pay a fee of 5s.

The examination will take place in the day or evening, according to the convenience of each candidate.

Intending candidates should at once communicate with the Secretary of the Society, stating if they desire to attend during the day or in the evening. They will then receive due notice of the day and hour fixed for their attendance.

INDIAN SECTION.

Friday, May 2nd; Sir P. CUNLIFFE OWEN, C.B., K.C.M.G., in the chair.

The Chairman, in introducing Mr. Wardle, said this evening's subject was one of the most practical results of the Paris Exhibition. There was nothing which more interested the French people than Mr. Wardle's collection, and India was specially honoured by the International Jury in receiving the Grand Medal of Honour for silks, as well as for tea. The manufacturers from Lyons were greatly interested in the Indian collection, notwithstanding it was contained in a very unpretending set of cases; and he must confess that when this matter was first brought under his notice by Dr. Birdwood, he did not think anybody could have had an idea of the practical results which would be achieved by Mr. Wardle's efforts. Mr. Wardle had been for some years employed by the India-office in making inquiries as to the development of this industry, and particularly as to the application of dyes from the plants to be found in the neighbourhood in which the silks were obtained. One could always see the mistakes which had been made after a thing was over, and he certainly thought those in charge of the Indian collection (of which he himself was one) might have taken more trouble in developing it. Mr. Wardle had great difficulties to contend with, but notwithstanding, he would repeat that the specimens of silk now exhibited were the most practical results of any International Exhibition, and Englishmen might be proud to think that the Empire of India had come out with such glorious results; but he was afraid many of them hardly realised what Mr. Wardle had done. The Lyons manufacturers, however, saw the importance of it; they were now in correspondence with him, and were anxious that he should come to Lyons, or, at any rate, that his paper should be translated, and read before the Lyons Chamber of Commerce.

The paper read was—

ON THE WILD SILKS OF INDIA, PRINCIPALLY TUSSER.

By Thomas Wardle, F.C.S., F.G.S.

INTRODUCTION.

This interesting and important subject has received so much learned attention during the last fifty years, from both entomologists and sericulturalists, that it is impossible now to treat of it in a lecture without saying much that is not absolutely new.

Whilst, therefore, abstract research may have but a narrow field left, I hope that what I have to say may be useful in stimulating a greater utilisation of these products, which are as beautiful as they are curious, and in calling the attention of manufacturers, printers, dyers, and users to some most important improvements and developments in each of their several departments, the result of a lengthened study of the exact nature of the fibres, and of new and improved modes of manufacturing and decorating them.

Amongst the many names of persons in various countries interested in the cultivation of wild silkworms, the utilisation of their products, and in the entomology of the subject, I venture to give the following list, which will be found interesting by many, and will serve to show more forcibly to what a large extent this important subject has been made a matter for study and investigation:—

English.

Dr. Roxburgh, Captain Hutton, Mr. Hugon, Dr. Birdwood, Mr. F. Moore, Mr. P. H. Gosse, Captain Mitchell, Mr. Butler, Major Coussmaker, Lady D. Neville, Lady Gilbert, Mr. Calvert, Mr. Geoghegan, Dr. Alex. Wallace, Dr. Mackenzie, and others.

Continental.

M. Guérin Méneville, M. Personnat, M. Robert, M. Camille Mayne, M. W. Reed, M. Braine, M. Maurice Girard, M. Wailly, Wilhelm Carl Berg, M. Costa, M. Matthieu Bonagous, Mich. Judizky, Roo Van Westmas, N. H. de Graaf, Dr. Chavannes, and many others. My friend M. Rondot, member of the Chamber of Commerce, Lyons, and President of the Jury Class 34, Silks, at the Paris Exhibition last year, author of several important works on silk and Eastern dyes, is at the present time giving much economic attention to this question, for the purpose of considering supply for the increasing demand of the French silk trade in wild silks.

Amongst those who have interested themselves especially in the utilisation of these wild silks must be mentioned Dr. Birdwood, who was one of the first, if not the first, to call public attention to the importance of Tusser silk, in a lengthy report to Government in 1858, which I regret I have not time to read.

Lady Dorothy Neville is well known by her efforts in trying to acclimatise the *ailanthus* worm, and in utilising its silk during a long series of observations of a practical nature.

Mr. Geoghegan is the author and compiler of a valuable report to the Government of India on the silk industry of India, which is indispensable to a study of the subject.

Major Coussmaker is pursuing with a praiseworthy determination, at Poonah, his culture of Tusser silkworms, with a view of making Tusser silk as systematic an industry as that produced by *Bombyx mori* and the other mulberry silks.

Besides many others, the enthusiastic labours of the French, aided by their Société d'Acclimatation, set us a great example. They have succeeded in domesticating, if not in almost naturalising, several eastern species of wild silk producers, and in obtaining from them silk of industrial value.

Classification.

The silk-producing *Lepidopterous* insects are of many species, possessing, as is here shown, very marked structural differences, whilst the variety and quiet beauty of their colours and, with the exception of the mulberry feeders, their large size, contribute greatly to the charm of studying this branch of natural history, and they make a collection, apart from their great usefulness, worthy of being placed in the first rank.

They belong, as I have stated, to the order *Lepidoptera*, and are all members of but two families, *Bombycidæ* and *Saturniidæ*.

All the *Saturniidæ* are silk spinners, but not all the *Bombycidæ*.

The British Museum catalogue contains the names of 294 species of *Saturniidæ*. Mr. Butler, of the British Musuem, informs me there have been 100 more species added since the publication of the catalogue.

The following table shows the position of these two families in the great system of classification of the animal kingdom:—

DIVISION III.

Articulata.

SUB-DIVISION II.

Anthropoda (or true articulata).

CLASS VIII.

Insecta.

SUB-CLASS III.

Metabola.

ORDER X.

Lepidoptera.

SUB-ORDER I.

Heterocera (Moths—8 groups or tribes).

GROUP.

Bombycina.

FAMILY 10.

Genera.—Bombycidæ.

Bombyx,	Ocinara,
Theophila,	Trilocha.

FAMILY 8.

Genera.—Saturniidæ.

Attacus,	Caligula,
Antheræa,	Neoris,
Actias,	Saturnia,
Salassa,	Loepa,
Rinaca,	Cricula.
Rhodia,	

Mr. Frederic Moore, curator of the India Museum, the acknowledged authority on Indian wild silk moths, has kindly furnished me with a

list of all the silk-producing *Lepidoptera* of India known at the present time.

The India Museum contains a collection of most of the wild silk moths, with specimens of the cocoons and the silk of their larvæ, arranged by Mr. Moore, a description of which will be found in the second volume of the catalogue on Indian *Lepidoptera*, published in 1858-9.

To illustrate my lecture, I have here to-night a very interesting collection of the moths of the greatest industrial importance, as well as the cocoons of their larvæ, and examples of their silk in most, if not all, the various stages of industrial development.

The following is Mr. Moore's list of all the known species of silk producers in India. It is the most valuable list yet published, and shows how rich India is in silk-producing insects :—

Mulberry-feeding Silkworms—Domesticated.

Bombyx mori (Linnæus).—The common silkworm, domesticated in China, Bokhara, Afghanistan, Cashmere, Persia, S. Russia, Turkey, Egypt and Algeria, Italy, France, and Spain, in all which countries it produces but one crop annually, spinning the largest cocoon and the best silk, of a golden yellow, or white.

Bombyx textor (Hutton).—The *Boro poolloo* of Bengal, domesticated in S. China and Bengal; an annual only, producing a white (sometimes yellow) cocoon, of a different texture and more flossy than *B. mori.*

Bombyx sinensis (Hutton).—The *Sina, Checna*, or small Chinese monthly worm of Bengal, partially domesticated in Bengal, where it was introduced from China: produces several broods in the year; cocoon white and yellow.

Bombyx crœsi (Hutton).—The *Nistry* or *Madrassee* of Bengal, introduced from China; domesticated in Bengal; yielding seven or eight broods of golden yellow cocoons in the year, of larger size than *B. sinensis.*

Bombyx fortunatus (Hutton).—The *Dasce* of Bengal yields several broods annually, spinning the smallest cocoon, of a golden yellow colour.

Bombyx arracenensis (Hutton).—The Burmese silkworm, domesticated in Arracan, said to have been introduced from China through Burmah; yields several broods annually; cocoons larger than the Bengal monthly species.

Mulberry-feeding Silkworms—Wild.

Theophila Huttoni (Westwood).—The wild silkworm of the N. W. Himalayas. A wild species, the worms being found abundantly feeding on the indigenous mulberry in the mountain forests of the N. W. Himalayas.

Theophila sherwilli (Moore).—The wild silkworm of the S. E. Himalayas.

Theophila Bengalensis (Hutton).—The wild silkworm of Lower Bengal. Discovered in the neighbourhood of Calcutta feeding on *Artocarpus lacoocha.* Found also at Ranchee in Chota Nagpore.

Theophila religiosæ (Helfer).—The *Jorec* of Assam and *Deo-mooga* of Cachar. Feeds on the bur tree (*Ficus indica*) and the pipul (*F. religiosæ*).

Theophila mandarina (Moore).—The wild silkworm of Chekiang, N. China. Worms stated to feed on wild mulberry trees, spinning a white cocoon.

Ocinara lactea (Hutton).—Mussooree, N.W. Himalaya. Feeds on *Ficus venosa*, spinning a small yellow cocoon, yielding several broods during the summer.

Ocinara Moorei (Hutton).—Mussooree, N.W. Himalaya. —Also feeds on *Ficus venosa*, as well as on the wild fig, spinning a small white cocoon. It is a multivoltine.

Ocinara diaphana (Moore).—Khasia hills.

Trilocha varians (Walker).—N. and S. India.

Atlas and Eria Group.

Attacus atlas (Linnæus).—China, Burmah, India, Ceylon, Java. This appears to be almost omnivorous, feeding in different districts upon the shrubs and trees peculiar to them. At Mussooree it is found upon *Bradleia ovata, Falconeria insignis*, and several other trees; at Almorah the yellow flowering barberry is said to be its favourite food. In Cachar it feeds on various other trees. Cocoon well stored with a fine silk.

Attacus silhetica (Helfer).—Silhet.

Attacus Edwardsia (White).—Sikkim, Cherra, and Khasia hills.

Attacus cynthia (Drury).—China. Domesticated in the provinces of Shantung and Honan. Feeds on the varnish tree (*Ailanthus glandulosus*).

Attacus Ricini (Jones).—The *Eria* of Assam, and *Arindi* of Dinajpore. Domesticated in the Northern parts of Bengal (Bogra, Rungpore, and Dinajpore), in Assam and Cachar, feeding on the castor-oil plant (*Ricinus communis*), yielding seven or more crops annually. Cocoons somewhat loose and flossy, orange red, sometimes white. The so-called "Ailanthus silkworm" of Europe—the result of a fertile hybrid between the Chinese and the Bengal species, was produced some years ago in France, by Monsieur Guérin-Méneville, and subsequently reared, from whence it was introduced into various parts of the world.

Attacus Canningi (Hutton).—N.W. Himalayas. Common in a wild state, feeding on the leaves of *Coriaria nipalensis* and *Xanthophyllum hostile.* Cocoons hard and compactly woven, rusty orange or grey. An annual.

Attacus lunula (Walker).—Silhet.

Attacus obscurus (Butler).—Cachar. Not very common. Stated to feed on a plant called *Lood.*

Attacus Guerini (Moore).—Eastern Bengal.

Actias Group.

Actias Selene (McLeay).—Mussooree, Sikkim, and Khasia hills; Madras. The worms feed upon *Andromeda ovalifolia, Coriaria nipalensis*, wild cherry, and walnut, at Mussooree, and on *Odina wodier* in Madras.

Actias Sinensis (Walker).—N. China.

Actias Leto (Doubleday).—Sikkim and Khasia hills.

Actias Mænas (Doubleday).—Sikkim and Khasia hills.

Actias ignescens (Moore).—Andaman Isles.

Tusser and Moonga Group.

Antheræa mylitta (Drury); *Antheræa paphia* of authors; the *Tusser, Tussar*, or *Tussah* silkworm.—These well-known and valuable insects (of various undetermined species) are widely distributed over India, from east to west and north to south, on the coast, and in the Central Provinces. They feed in a wild state upon the ber (*Zizyphus jujuba*), the asun (*Terminalia alata*), the seemul (*Bombax heptaphyllum*), &c.

Antheræa mezankooria (Moore); the *Mezankoorie* silkworm of the Assamese.—The worms which produce the mezankoorie silk are stated to feed on the addakoory (? *Tetranthera sp.*), which is abundant in Upper and Lower Assam. The silk is nearly white, its value being fifty per cent. above that of the moonga.

Antheræa nebulosa (Hutton).—This is the *Tusser* of the Sonthal jungles of Colong. It is also found in Singbhoom, Chota Nagpore.

Antheræa Perrotteti (Guér. Mén.).—Described as being found in the districts of Pondicherry, feeding upon a species of *Zizyphus*, the jambool (*Syzygium jambolanum*), &c. Stated to produce four broods in a year.

Antheræa Andamana (Moore).—An allied species to the tusser. Inhabits the S. Andamans.

Antheræa Frithi (Moore).—Sikkim Himalayas. A common species, inhabiting the hot sub-tropical valleys below 2,000 ft. Known only as a wild species. The cocoon is stated to be similar to that of the tusser in form, but of finer silk.

Antheræa Helferi (Moore).—Sikkim Himalayas. This is a common species found in the hot valleys of Sikkim.

Antheræa Assama (Helfer).—The *Moonga* or *Mooga* of the Assamese. The moonga silkworm feeds upon the trees known in Assam as the champa (*Michelia sp.*), the soom, kontoolva, digluttee (*Tetranthera diglottica*), the pattee shoonda (*Laurus obtusifolia*), and the Sonhalloo (*Tet. macrophylla*). It is extensively cultivated by the natives, and can be reared in houses, but is fed and thrives best in the open air and upon the trees. The silk forms an article of export from Assam, and leaves the country generally in the shape of thread.

Antheræa Roylei (Moore).—The oak-feeding silkworm of the N. W. Himalayas. A common species, feeding on the hill oak (*Quercus incana*) of the N. W. Himalayas (Simla, Masuri, Almora). The cocoon is large and very tough, the silk being pronounced as promising, and worth cultivating. They can be reared easily in the house.

MISCELLANEOUS GROUP.

Salassa Lola (Westwood).—Sikkim Himalayas.

Rinaca Zuleika (Hope).—Sikkim.

Rhodia Newara (Moore).—Nepal (Kathmandoo). Worms feed upon a species of weeping willow. Spins a brilliant green cocoon, pendant from the twigs.

Caligula Thibeta (Westwood). — Mussooree, N.W. Himalayas, 7,000 ft. Common, the worms feeding on *Andromeda ovalifolia*, wild pear, and the cultivated quince, forming a light, open, net-like cocoon.

Caligula Simla (Westwood).—Simla, N.W. Himalayas, 5,000 ft. Feeds on the walnut, *Salix babylonica*, wild pear, &c. ; forms an open, net-like cocoon.

Caligula Cachara (Moore).—Cachar.

Neoris Huttoni (Moore).—Mussooree, N.W. Himalaya, 6,500 feet. The worms appear in April, feeding upon a species of wild pear tree; spins a thin silken cocoon.

Neoris Shadulla (Moore).—Yarkund.

Neoris Stoliczkana (Felder).—Ladak.

Saturnia Cidosa (Moore).—Hot valleys of the Sikkim Himalayas.

Saturnia Grotei (Moore).—Sikkim, Himalayas.

Saturnia Lindia (Moore).—Sikkim, Himalayas.

Saturnia Anna (Moore).—Sikkim, Himalayas.

Loepa katinka (Westwood).—Sikkim, 5,000 to 7,000 feet. Assam.

Loepa sikkima (Moore).—Hot valleys of Sikkim.

Loepa sivalica (Hutton).—Mussooree, 5,000 feet. Spins a long cocoon, pointed at each end, and of a dark greenish-grey colour.

Loepa miranda (Moore).—Sikkim, Himalayas.

Cricula trifenestrata (Helfer); the *Haumpottonee* of the Assamese.—Noted as being very common in Assam, the worms feeding on the soon tree, forming an open net-like cocoon of a beautiful yellow colour and of a rich lustre, the silk being spun in the same manner as the Eria cocoon. Occurs also in Moulmein, where the worms are stated to feed upon the cashew-nut tree (*Anacardium orientale*).

Cricula drepanoides (Moore).—Sikkim.

To this number may be added a few others which, although not of India, are well worth the attention of the Government of India for the purpose of acclimatisation there.

Antheræa Pernyi (Guér. Mén.)—The oak-feeding silkworm of Mantchouria, N. China. This is described as having been long known to the Mantchour Tartars, very large quantities of the silk being used among the Chinese. The worms feed on various species of oak (*Quercus mongolica*) &c., the cocoon differing from the tusser in form and texture. The silk is represented as strong, but with little lustre. Two crops of silk are produced in the year—a spring and autumn crop.

Antheræa Confuci (Moore).—A species allied to *A. pernyi*, inhabiting the hills in the neighbourhood of Shanghai, N. China.

Antheræa Yama-mai (Guérin Méneville).—The *Yama-mai* silkworm of Japan.

An oak-feeding species, forming a cocoon of a pale yellowish-green colour. This worm feeds on the oak, and produces excellent silk of considerable commercial value in Japan. I should strongly recommend its introduction into India. It has been acclimatised in Europe, and crossed with *Bombyx Attacus—Pernyi*, is successfully reared in France, the eggs hatching at almost freezing point. The silk is much cultivated and used in Japan. Its fibre is oval, and 950th of an inch thick.

Saturnia pyretorum from South China.—The worm feeds upon the *Liquidamber formosanu* in Canton, Amoy, where the silk is stated to be woven into a coarse fabric.

Neoris shadulla (Moore).—Yarkund.

Theophila mandarina (Moore).—N. China.

HISTORY OF SILK.

A few words on the silk of commerce and its history may form a fit preface in introducing to your notice those wild silks which it is my object to describe to-night.

The name silk is derived from the name of the people of Eastern Asia, whom the ancient Greeks called Σῆρες, Seres, and who, no doubt, were the Chinese, and who were then, as now, celebrated for silken fabrics or seric stuff.

From seres comes the Latin *sericum*, the French *soie*, the German *seiden*, the Anglo-Saxon *seolc*, the Icelandic *silki*, and the English *silk*.

We are informed by Hawae-nan-tze, in a Chinese work called the "Silkworm Classic," that Teling-she, the principal queen of Hwang-te, B.C. 2640, was the first to rear silkworms, and the Emperor Hwang-te was induced to invent robes and garments from this circumstance.

The queen and wives of the nobles through successive generations personally attended to the rearing of the silkworms. Alas! that, in these days of expediency, hurry and greed, the faith in machinery should have so disastrously stifled the better faith in manipulation, both in silk handicraft work and the old love for the spinning wheel, to the detriment alike of all classes, from the noble to the low born, who have been robbed of much that in bygone days contributed to the comfort, occupation, and enjoyment, especially of the gentler sex. Surely here is a worthy object of reform for our national art schools. That this silk was of the mulberry-fed kind is evident from a further extract from the same work, which says that afterwards, "when Yu regulated the waters B.C. 2200, mention is made in his work on the tribute of the land adapted for the mulberry tree having been supplied with silkworms, from which time the advantage thereof gradually increased." Horsfield and Moore's Catalogue, p. 377.

It is not known whether silk was utilised in India

at so early a period as this, probably not, but that India learned the art from China is generally understood, although at what period is not known.

For more precise information respecting the westward spread of silk culture I would strongly recommend my hearers to read Dr. Birdwood's account in his handbook to the British India Section of the Paris Exhibition. This learned history of silk will be read with much pleasure by all who can see in silken stuffs something more than a mere commercial value. The account of its utilisation and spread from East to West is described with almost the charm of romance. Its development is traced from its earliest days in the East to its introduction at last into our own country in the reign of Henry VI., and again to those sad French times of the persecution of the religious Huguenots by Louis XIV., which drove their silk workers by a happy tide to our shores. How that tide has in our own times returned to France, and carried with it not the workers, but the industry, I leave for statesmen—and they have much to answer for—and manufacturers to think over and retrieve.

Europe may be said to have got hold of the silk industry by a fraud; two monks are said to have brought away the eggs from China concealed in their walking canes. A similar account is well related by Dr. A. Wallace of the way the eggs of the prized Yama-mai silkworm were abstracted from Japan by a young Japanese, who obtained them at the instigation of his European tutor at the risk of his life, for this was an offence there punishable by death. It would be but a small return for the benefits we have obtained to ourselves by these frauds if we could teach those weaker peoples the benefits of the better making, and above all the more friendly interchanging of stuffs and commodities. It is with this hope that I put the wild silk question before the Society of Arts, that, having India, with its extensive wild silk regions, in our possession, we may, by gentle means, teach the natives to improve the culture and preliminary stages of its manufacture; so that it may be brought from them in a state fit to be used by us for all the purposes of which, in its improved state, it is really capable, and, to use the words of Sir Louis Mallet in the first letter of instruction I received from the India-office, that "a new and very profitable industry may be founded in India."

The natural history of every kind of silk may be briefly stated to be this. From a small egg laid by the moth, of whatever species, appears in due season a small larva, or caterpillar, or worm, as it is usually called. This worm, after having lived its day, feeding only on the leaves of certain plants characteristic of its species, spins, or rather secretes, a fine thread of silk around itself, for covering and protection during the time it lies dormant in the next stage of its existence. As soon as it has secreted all the silk, it changes into a pupa or chrysalis, and remains inside its silken cell until the time comes for its appearance as an imago, or perfect insect, having four scaly wings, legs, and antennæ. When its hybernation is ended, it emits a fluid which softens the end of its cocoon cell, and by means of its wing spines and legs, parts the fibres aside until the opening is large enough for it to creep out. After a short time, its wings dry and expand, and it has entered into its perfect state. It lives only a few days in this phase of its existence. It is in this stage only that the race is perpetuated, the female laying a number of eggs, and dying soon afterwards.

Bombyx Mori.

What is generally known as the silk of commerce, in both ancient and modern days, is distinguished from all others by the singular circumstance of the larvæ which produce it feeding on the leaves of the mulberry tree. The moth is therefore named *Bombyx mori*.

It must not be inferred, however, that there is only one species, as is too generally thought. Mr. F. Moore assures me there is sufficient structural variation in moths, which were at one time understood as *Bombyx mori*, to constitute specific differences. The following species feed on the mulberry, and their silk is in ordinary and promiscuous use along with that of the *mori*:—

Bombyx sinensis (Hutton),
Bombyx crœsi (Hutton),
Bombyx fortunatus (Hutton),
Bombyx arracanensis (Hutton),
Bombyx textor (Hutton),

and no doubt several others not yet defined, but whose silk varies very much, such as that called Canton, and that called Tsatlee, although both are from China, as well as the silk from Japan, which has a thicker fibre than the Mori silk of other countries, being $\frac{1}{1650}$ of an inch thick, as against $\frac{1}{2100}$ of an inch of the Mori silk of Italy. The strength and tension of this and the wild silks, as well as the respective sizes of their cocoons, are given in the table of microscopic measurements which I have carefully revised for my lecture, confirming generally, but in several instances correcting those I made for my monograph for the Paris Exhibition.

I have here some beautifully-prepared Italian silks of *B. Mori*, kindly lent to me for my paper by my friend M. H. Meyer, a large silk manufacturer at Milan.

The eggs of *Bombyx mori*, and the other species of *Bombyx*, form a most important article of commerce between Japan and Europe. They are imported from thence into Italy and the South of France annually, to supply the deficiency caused by the silkworm disease known as *pebrine*, and also to infuse, as it were, new blood. The value of the eggs is about 25s. per oz. Twelve pounds of cocoons are required to produce 1 lb. of silk. The value of the raw silk of Bengal in London is now 14s. 6d. per lb. The colour is generally of a rich golden yellow of this sample, but it is also sometimes white. In China and Japan it is all white, with rare exceptions.

Wild Silks.

As far as I can learn, the only species of cocoons at present utilised in India, besides those of the several species of mulberry-feeding worms of the genus *Bombyx*, are the wild ones of the following species:—

Attacus ricini,
,, cynthia,
,, atlas,
,, edwardsia.
Antheræa assama, or Munga worm,
,, paphia, or Tusser worm,

Antheræa perotteti,
,, nebulosa,
,, roylei,
,, frithii,
,, mezankooria.
Cricula trifenestrata.
And, perhaps,
Attacus selene and Antheræa helferi.

The India localities of the four principal ones, Ricini, Atlas, Munga, and Tusser, are shown on these maps by various colourings.

THE ERIA SILKWORM.

We now arrive at the consideration of the Eria, Arindy or Arundi worm, of which there are two species, *Attacus ricini* and *Attacus cynthia*, *Attacus ricini* (Boisd.) is known also under the names *Saturnia ricini* (Boisd.), and *Attacus lunula* (Walker).

Attacus ricini is a worm which feeds on the Palma christi, or castor-oil plant, *Ricinus communis*. It is a native of Assam, and, according to Mr. Geoghegan, is found to the south-west in a track comprising the districts of Nepaul, Kumaon, Ladak, Darjeeling, Dinagepore, Rungpore, and, perhaps, parts of Bhangulpore, and Purmiah, and in Assam. In 1791, Sir W. Jones drew attention to this silk, and Dr. Roxburgh inh 1804.

The leaves of the castor-oil plant, *Ricinus communis*, or Palma christi, are the best and commonest food, but it will also feed on the following:—Koosool, Hindoo grass, Murkurdal, Okonnee, Gomaree, Litta pakoree, Birzonally, *Xanthoxylon hostile*, *Coriaria nipalensis*, *Ailanthus glandulosa*, *Ailanthus excelsa*.

Attacus ricini is of a larger size than *Attacus cynthia*; owing probably to its freedom, and there is no doubt it is a silk producer of great importance in India. Probably the most complete account of it is by Mr. Geoghegan in his report on the silk industry of India, of which I avail myself to gather some useful particulars.

The *Attacus ricini*, according to Dr. Buchanan, feeds both on *Ricinus communis* and *Ricinus viridis*.

The female moth lays her eggs round a twig, and then dies. These twigs are sold in the markets covered with eggs, the dead moths frequently hanging to them, and presenting a very curious appearance.

The caterpillar moults four times, and when fully grown is about $3\frac{1}{2}$ inches long.

According to Mr. Hugon, the natives soften the cocoon in potash, and draw the silk off roughly with the finger and thumb, thus making a kind of spun silk. Dr. Buchanan, however, says the silk is wound on a reel in Dinagepore.

M. Guérin Méneville, however, stated in 1860, that it was impossible to reel this cocoon. I am certainly disposed to think it is quite impracticable. Still, there is a method of using it at hand, and I know of no silk better adapted for spinning.

Some of the cocoons I received from the India-office for examination I have had carded or dressed, and the result is, as is shown in this sample, a fibre of great fineness and length, which would be eagerly sought after by English and Continental spinners, if the cocoons could be collected and sent over in quantity. Owing to the very small quantity of cocoons in my possession, I am sorry I have not been able to have specimens of yarn or cloth made for my lecture, but I have here native spun yarn undyed, bleached and dyed, also native woven cloth in the undyed and dyed states, as well as specimens of prints executed on it for, I believe, the first time in its history or use. The cloth is beautifully soft.

I find no difficulty in making this silk yield to tinctorial influences, either in dyeing or printing, and I have no hesitation in predicting a great future for it, as soon as it is subjected to the better spinning appliances of Europe, and I am recommending the Government of India to give all possible encouragement to the importation of Eria cocoons into Europe.

Dr. Helfer, in 1837, stated in the *Journal of the Asiatic Society of Bengal*, that this worm is so productive as to give sometimes twelve broods of silk in the course of the year. The worm grows rapidly, and offers no difficulty whatever for an extensive speculation.

The industry of the natives of India should be stimulated to the gathering in of all kinds of wild silk cocoons, whether windable or not, for there is no doubt that those kinds which cannot be reeled can be most easily spun, and there is at the present moment a request on the part of silk spinners for a much larger supply of Tusser silk cocoons and Tusser silk waste for spinning purposes, and no doubt the other wild silk cocoons would be gladly bought up, especially those of *Attacus ricini*.

Mr. Geoghegan says, with regard to the thread from cocoons of *Attacus ricini*, that a seer of 96 sicca weight ($2\frac{464}{1000}$ lbs.) of this thread is worth from annas 12 (one shilling and sixpence) to Rs. 1 (two shillings), but it is very seldom sold, and the people who keep the insect in general rear no more than is just sufficient to make cloths for their own families. The cloth lasts very long, owing to which quality it is probable that some use might be found for this material in our manufactures at home.

Mr. Michael Atkinson, of Singapore, describes the cloth made of Eria to be of incredible durability, the life of one person being seldom sufficient to wear out a garment made of it, so that the same piece descends from mother to daughter. The thickness of this fibre is $\frac{1}{1500}$ of an inch on the outside of the cocoon, and $\frac{1}{1450}$ in the inner part. (For other particulars see Table.)

Mr. Hugon says that, "in Assam, the quantity of Eria cloth the merchants formerly used to take away was very considerable, but in the latter years of the Assam Rajah's rule, from the disorganised state of the country the number of merchants gradually diminished. The quantity the country is capable of exporting under an improved management would be very large, for it forms at present the dress of the poorer classes at all seasons, and is used by the highest for winter wear. So long ago as 1769, vast quantities were being produced in the country around Guraghaut." He estimated the annual production at 1,000 maunds, or 82,000 lbs. "In the district of Durlung, the annual yield of Eria is 1,000 maunds, of which one-third is exported either in the form of cocoons or woven into heavy cloths (Borkapor)." Mr. Hugon stated that, for want of a proper solvent of the gum, the natives could not reel the cocoons. Mr. Brownlow states that in Cachar, the Eria or Ricini worm is trained by the Cacharis, a people living

TABLE

OF THE DIAMETER, STRENGTH, AND TENSION OF A SINGLE FIBRE AND DIMENSIONS OF COCOON OF THE CHIEF MULBERRY AND INDIAN WILD SILKS.

Name of Worm and Silk.	Country.	Diameter in fractions of an inch.		Strength of single fibre in drams averdupois.		Tension or limit of stretch before breaking in inches of single fibre one foot long.		Dimensions of cocoons in inches.
		Outside of cocoon.	Inner part of cocoon.	Outside of cocoon.	Inner part of cocoon.	Outside of cocoon.	Inner part of cocoon.	
Bombyx mori, or Mulberry Silk	China	$\frac{1}{2150}$	$\frac{1}{2150}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{3}{8}$	$2\frac{7}{8}$	$1\frac{1}{8} \times \frac{1}{2}$
	Italy	$\frac{1}{2150}$	$\frac{1}{2100}$	1	$1\frac{3}{4}$	$2\frac{5}{8}$	$2\frac{7}{8}$	$1\frac{1}{4} \times \frac{5}{8}$
	Japan	$\frac{1}{1800}$	$\frac{1}{1650}$	1	$1\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{7}{8}$	$1\frac{1}{8} \times \frac{5}{8}$
	Bengal	$\frac{1}{2000}$	$\frac{1}{2200}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$2\frac{1}{8}$	$2\frac{3}{8}$	$1\frac{1}{4} \times \frac{1}{2}$
Bombyx textor	India	$\frac{1}{2500}$	$\frac{1}{2500}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{2}$	$1\frac{1}{4} \times 1\frac{1}{2}$
Antheræa paphia, or Tusser Silk	,,	$\frac{1}{770}$	$\frac{1}{710}$	1	1	7	8	$1\frac{1}{2} \times \frac{7}{8}$
Attacus ricini, or Eria Silk	,,	$\frac{1}{1500}$	$\frac{1}{1430}$	1	$1\frac{1}{2}$	$1\frac{7}{8}$	$2\frac{1}{8}$	$1\frac{1}{2} \times \frac{3}{4}$
Attacus cynthia, or Ailanthus Silk	,,	$\frac{1}{1250}$	$\frac{1}{1250}$	1	$1\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{2}$	$1\frac{3}{4} \times \frac{3}{4}$
Anstheræa assama, or Muga Silk..	,,	$\frac{1}{1430}$	$\frac{1}{1080}$	1	$1\frac{3}{4}$	$2\frac{1}{8}$	3	$1\frac{3}{4} \times 1$
Actias selene	,,	$\frac{1}{1000}$	$\frac{1}{1100}$	1	$1\frac{1}{4}$	2	$2\frac{1}{4}$	$3 \times 1\frac{1}{4}$
Attacus atlas	,,	$\frac{1}{1320}$	$\frac{1}{1000}$	1	$1\frac{1}{4}$	$2\frac{1}{8}$	$2\frac{1}{2}$	$3\frac{1}{2} \times \frac{7}{8}$
Antheræa yama-mai	Japan	$\frac{1}{1000}$	$\frac{1}{1000}$	$\frac{3}{4}$	$1\frac{3}{4}$	$2\frac{1}{8}$	3	$1\frac{1}{2} \times \frac{7}{8}$

in isolated villages on the hills. They soften the cocoons in a mixture of cow dung and water, and they are then carried off to a spindle by the women of the tribe. This silk is dyed by the natives with lac, mungeet, and indigo.

ATTACUS CYNTHIA.

Attacus cynthia (Drury).
Phalæna attacus cynthia (Drury).
Phalæna cynthia (Roxburgh).
Bombyx cynthia (Oliver).
Samia cynthia (Hübner).
Saturnia cynthia (Westwood).
Saturnia arrundi (Royle).
Eria of Assam (Hugon).

I have mentioned the close relationship of *Attacus cynthia* to *Attacus ricini.*

Mr. Geoghegan says *Attacus cynthia* occurs in a wild state throughout a great part of the Himalaya, in the Dehra Doon, and in Assam and Cachar.

In China, *Attacus cynthia* feeds on *Ailanthus glandulosa*. During the last 20 years much study has been bestowed on the species in Europe, and it has been successfully domesticated in France, and later on in England, so much so, that this study rejoices in the name Ailanthiculture, and the breeding houses of the insect are called Ailantheries.

It is to M. Guérin-Méneville, in France, and to Lady Dorothy Neville, in England, that we are indebted for leading the way to the successful rearing of the *Attacus cynthia*. A description of their labours will be found in a memoir by Dr. Wallace, published in 1866, in the *Journal of the Entomological Society*. Besides giving full particulars of all that relates to Ailanthiculture, Dr. Wallace describes with great minuteness his own experience in producing this silk. He received the prize offered by the Council of the Society in 1865, for an essay on "Economic Entomology."

The diameter of all the fibres in the cocoon is tolerably uniform, and about $\frac{1}{1250}$ inch. The strength of the outer fibres is, however, only $2\frac{1}{4}$ drams, that of the inner being $2\frac{1}{2}$ drams. The tension of the outer fibres is one inch to the foot, and of the inner $1\frac{1}{2}$ inches. All the fibres are flat and longitudinally striated, and united in pairs by their edges. The cocoon is about the size of a thrush's egg, $1\frac{1}{2}$ to $2\frac{1}{4}$ inches long, and $\frac{3}{4}$ of an inch in diameter, and consists of very fine silk, rather loosely, but closely laid together. It offers great difficulty in winding, and I am not aware that this has yet been successfully accomplished, I mean commercially.

In 1864, M. Forgemol informed the Imperial Society of Acclimatisation, in France, of the particulars of a mode he had invented to reel this silk. Dr. Wallace has quoted this report, describing the method, in his memoir. I fear, however, it is not now in practical use. But whether the reeling has ever been done, or ever will be, or not, there is no doubt that a great future remains for this silk, now that spinning machinery has been so perfected. All the cocoons that could be bred, would be easily bought up by the silk spinners. The thickness of a single inner cocoon fibre is about $\frac{1}{1430}$ of an inch, and an outer fibre about $\frac{1}{1500}$ of an inch. Throughout the cocoons are a few pairs of fibres $\frac{1}{3750}$th of an inch in diameter. The breaking strength of a single fibre is 75 grains, and the tension is about two inches for every twelve inches, *i.e.*, a fibre twelve inches long stretches to fourteen inches before it breaks.

Attacus cynthia came originally to India from China. In 1856 cocoons were sent by Abbe Fantoni from the province of Shan Tung in the North of China.

Succesful breeding took place from these cocoons in Turin in 1857, and from these spring all those which have been since cultivated in France, England and other European countries. Mr. Moore was the first to rear them in England in 1859.

Dr. Wallace gives a lengthened account of the tree on which *Attacus cynthia* best thrives, *Ailanthus glandulosa*, from which I extract the following interesting remarks:—

"The genus *Ailanthus* belongs to the family *Rutaceæ*, and to the tribe *Xanthoxyleæ*, or yellow woods. It is a

large and beautiful tree, reminding us somewhat of the walnut. The leaf stalks are of great length; some I have measured were three feet and a half to four feet long, pendant with a graceful curve at the lower third of their length; the leaflets are large, some measuring eight and a half inches in length by three in breadth, from thirteen to seventeen on a leaf-stalk; near the base of the leaf the margin is toothed, and at the extremity of the tooth is a little gland, emitting a strong resinous odour, whence the name glandulosa; of these teeth and glands there are generally two, three, or more on each leaflet. The same odour seems to be communicated more or less to the leaf, also to the larva, and in a less degree to the imago of *Attacus cynthia*."

The pupæ of this insect remain in the cocoon through the winter, except in those cocoons which are formed in the autumn, from which they emerge in three or four weeks. The remaining moths emerge in April, and pair in about 12 hours afterwards, and the female begins to lay her eggs almost immediately. The moths do not live long after their exit from the cocoon. About eight days is the duration of their existence in this last and perfect stage. The eggs of one female vary from 150 to 350—30 of them weigh a grain. They hatch in 12 to 18 days, according to temperature. In seven days the tiny caterpillars complete their first stage by moulting, their second in five or six days after, being, up to this time, gregarous; their third moult occurs in another six days, and their fourth and last in six days more. By this time the larvæ are four inches long, and begin to spin their cocoons. *Attacus cynthia* has two broods in the year.

ATTACUS ATLAS.

The next silkworm to which I wish to draw your attention is the *Attacus atlas* of Linnæus, which is also known by the following names:—

Phalæna-Attacus atlas (Linn.).
Bombyx atlas (Fabricius).
Saturnia silhetica (Helfer).

The imago of this species is the largest of all the silk moths. As you will see in the case, it is a grand insect. It is called in France, "Le Géant des Papillons." The largest specimens measure upwards of 10 in. in expanse of wing. According to Horsfield, it feeds on the melokka (*Phyllanthus emblica*), a plant known also in India as *Kupu gaga*. Mr. Geoghegan says this silkworm is found in Mussooree on the *Falconeria insignia*, *Bradleia ovata*, and other plants; in Kumaon, on the barberry, where it is abundant, and also eastward to Cachar. Mr. Moore describes it as almost omniverous. Mr. P. H. Gosse has just written a most interesting life-history of this species, describing all that is known of it. His paper, from which I quote a few pertinent facts, will be found in the *Entomologist* of February and March last. He says:—

"It is a widespread species, ranging over the south and east half of Asia, continental and insular; common on the slopes of the Himalayas, and all through India to the points of both peninsulas; abundant in China; scattered over the isles of the Archipelago, from Java to the Moluccas, to Borneo and th ePhilippines, a range of 35° of latitude and 55° of longitude."

His efforts to breed the Atlas worm in England are described, and although he has not been very successful, owing to sickness and death in the larval stage, his account is very interesting. Captain Landy, of Surbiton, has succeeded in obtaining fifteen good cocoons from twenty-four eggs, the larvæ having been fed on the common barberry. Mr. Gosse has fed his on the sallow, others on the plum and apple-tree leaves. He states that all the family of *Saturniidæ* are very polyphagous.

It is interesting to observe the micaceous or window-like spot on each of the four wings. These, although characteristic of the *Saturniidæ* are almost more largely developed in *Attacus atlas* than in any other species. The French call these vitreous membranes *porte miroirs*.

There are several varieties of *Attacus atlas* which show their divergence from the type, by the variations of these fusiform window-like ornamentations. In some they are single, in others double.

The diameter of the external fibres of the cocoon is very variable, averaging about $\frac{1}{1320}$ inch, whilst that of the internal fibres is more uniform, and about $\frac{1}{1000}$ inch. The outer fibres are capable of supporting an average weight of $2\frac{1}{8}$ drams, and the inner $2\frac{1}{2}$ drams. The tension of the outer fibres is one inch to the foot, and the inner $1\frac{1}{4}$ inches. The fibres are flat and longitudinally striated, and united in pairs by their edges.

The egg of *Attacus atlas* is $\frac{8}{100}$ of a inch long. The larvæ moult six times. The cocoon of *Attacus atlas* is from two to three inches long, and about one inch wide at the widest part, and weighs two grammes, or the $\frac{1}{14}$th of an ounce.

Mr. Gosse says "the colour of the cocoon is a light umber, or drab; its surface (independently of the impress of leaves) roughly granular, scarcely at all silky or floccose, except at the mouth; its substance thin, parchmenty, very firm; the interior very smooth, and even subglossy. The upper extremity forms a natural orifice for the exit of the moth, made by the conveyance of a great number of silk-fibres, which are left ungummed, and are thus soft and flossy, the gummed, stiff silk passing up on one side, and contracting into the cord. Thus the cocoon is not closed, like those of *Bombyx mori*, of *Telea*, of the *Antheræa*, but open, like those of *A. cynthia*, of the *Samiæ*, of the *Saturniæ*. As a result of this structure, the exit of the imago leaves no disturbance behind, no witness, no disarrangement of these soft fibres, such as is the case with Yama-mai, Pernyi, and Mylitta."

Mr. Geoghegan states the silk to be difficult to reel, though it reels partially if boiled with vinegar. Captain Hutton says the silk is decidedly good, and Dr. Chavannes, of Lausanne, states it to be desirable of introduction into France. He says the worm is the Fagara of China, where it has long been cultivated.

ATTACUS EDWARDSII.

In the India Museum there are two specimens of an atlas moth, from Darjeeling, of an intensely dark colour, and possessing sufficient structural divergence from *Attacus atlas* to warrant Mr. Moore's affirming it to be a distinct species. It has been named *Attacus Edwardsia*. Mr. Gosse has the following interesting note respecting it:—

"As Darjeeling is 7,000 feet above the sea, and has a climate in which rain and snow are abundant in winter, and humidity is constant, it surely would not be difficult

to acclimatise this noble form (be it variety or species) in the British Isles."*

THE MOONGA, MOOGA, OR MUGA SILK.

I have here a silk produced from the worm known as the *Moonga*, or *Mooga*, *Antheræa assama* (Helfer), and *Saturnia assama* (Westwood). It is found in Assam, and also sparingly in the Dehra Doon, and is the next in importance to tusser. Mr. Geohegan's description of this silk occupies three pages of the Blue-book on the silk industry of India, from which I abstract the following particulars:—

"The worm that gives the common fawn-coloured moonga silk, when fed on the most common plants, gives a whitish silk when fed on the leaves of other silk. The plants it feeds on are named and estimated as follows:—

"No. 1. *Champa* (*Michelia*).—The silk produced from the worm feeding on this plant gives the finest and whitest silk, used only by the rajah and great people, and is called champa pattea moonga. The thread is sold at from 11 to 12 rupees a seer (11s. to 12s. per lb.)

"No. 2. *Maizankurry* (called also addakurry).—The old trees are cut down and the jungle about burnt, and the worms are fed upon the tender leaves of the offshoots for one year, when the leaves become too old and hard for the worms. Silk is sold at 6 to 7 rupees per seer (6s. to 7s. per lb.)

"No. 3. *Soom.*—This is the common tree of the vicinity; the silk from the worms fed on this gives the finest sort of fawn-coloured moonga. Silk is sold at $3\frac{1}{2}$ to 4 rupees per seer (3s. 6d. to 4s. per lb.)

"No. 4. *Soonhalloo Tetranthera macrophylla.*—This is also a brown silk of inferior quality. This plant is most common in Dhurumpore and about Russa Chokey.

"No. 5. *Digluttee Tetranthera diglottica.*—This is also brown silk of inferior quality, but the worms fed on the leaves of this tree increase much in size.

"No. 6. *Pattees hoonda Laurus obtusifolia.*

"The moonga worm gives broods five times a year, and the cocoon is very large, but thin. I could only obtain silk, the produce of worms feeding on Nos. 3 and 4, and manufactured into cheap cloths for the lower classes.

"In its natural fawn-colour it stands washing much better than ordinary silk, keeping gloss and colour till the last.†"

Mr. Geoghegan, on page 114 of his "Silk Industry of India," says:—

"The cycle of the insect is thus given:—

From emergence from the egg to commencement of cocoon .	30 days.
In the cocoon................	20 ,,
As a moth	6 ,,
In the egg	10 ,,
Total..........	66 days."

In 1873, Colonel Hopkinson, the Commissioner of Assam, gave more modern figures:—

"It thence appears that the soom forests (on which the worm is chiefly fed) cover an area of about 34,000 acres, of which about 18,000 are assessed, yielding a revenue of nearly Rs. 28,000 (£2,800). By far the greater portion of the assessed area lies in the district of Sibsagar. The production of the silk is said to employ some 48,000 persons, but it is not their sole calling. The outturn of silk is estimated at upwards of 100,000 lbs. But as it is admitted that the greater part of the silk is reserved for home manufacture, this estimate cannot be regarded as absolutely trustworthy. The price of the yarn per seer (2 lbs.) varies from Rs. 5 (10s.) to Rs. 9 (18s.) in the several districts. The small portion exported goes to Calcutta and Dacca. From the former place it is said to find its way, to some extent, to Bhangulpur and Bombay."

"The Silk Committee of the Agri-Horticultural Society reported favourably on some munga silk sent down by Captain Jenkins in 1839, and expressed their opinion that the article was calculated to become of extensive and valuable use to our home manufactures."*

One acre of land yields 50,000 Muga silk cocoons, which yield upwards of twelve seers (24 lbs). of silk, price Rs. 5 per seer, or 5s. per lb.

From Mr. Hugon's description of the mode of reeling, it is evident it is of the rudest kind, and points to a remedy in the improved continental reeling appliances.

The following particulars by Mr. Hugon in 1834 are interesting:—The Muga silk industry is confined to Assam and some Tipperah villages. The quantity of land planted with food for the muga was 5,000 acres, capable of yielding 1,500 maunds (123,000 lbs.) of silk. This silk formed one of the principal exports of Assam. The average quantity was 257 maunds (21,070 lbs.) valued at Rs. 56,054 (£5,605), leaving the country principally in the shape of thread. He advocates the use of the moonga silk in coloured fabrics, it being easily dyed.

Having only a very small quantity of coarse reeled Muga silk at my disposal, my experiments with it have been limited. I find it bleaches well, is very lustrous, and takes the dye freely, better than Tusser. Here are specimens of it in the raw, boiled-off, bleached, and dyed states, and also some waste from cocoons for spinning.

The diameter of the fibres of Muga silk taken from the external part of the cocoon averages $\frac{1}{1430}$ inch, but the external fibres are very variable. The diameter of the inner and less variable fibres is $\frac{1}{1080}$ inch. The outer fibres will break with a weight of $2\frac{1}{8}$ drams on the average, but the inner will support three drams. The tension of the outer fibres averages one inch to the foot, and of the inner $1\frac{3}{4}$ inches. All the fibres are like Tusser, flat and striated, and united in pairs by their edges.

The following table is given by Mr. Hugon, showing the nature and prices of the various kinds of cloth made from Moonga silk:—

Name of Cloth.	Size of Yards and Inches.	Weights.	Price of Tread.	Cost of Weaving.	Total.	Remarks.
		lbs. oz.	s. d.	s. d.	s. d.	
Goovias	4 × 30 in.	0 12	3 9	0 $4\frac{1}{2}$	4 $1\frac{1}{2}$	Dhoties.
Ditto	9 × 1-4 in.	2 0	10 0	1 0	11 0	Dhoties.
Mekla	$2\frac{3}{4}$ × 1	0 8	2 6	0 3	2 9	Petticoats.
Rhia	$6\frac{3}{4}$ + $\frac{3}{4}$	1 0	5 0	0 6	5 6	Scarfs.
Gaursha	$4\frac{1}{2}$ × 20 in.	0 4	1 3	0 $1\frac{1}{2}$	1 $4\frac{1}{2}$	Worn as turbans, or round the waist.
Joonta Bor Cappor	$6\frac{3}{4}$ × $1\frac{1}{4}$	2 0	4 0	0 9	4 9	Made of the floss, and worn in winter.

* Gosse's "Life History of *Attacus atlas*," p. 6.
† "Geoghegan, Silk Industry of India," p. 25.

* "Geoghegan, Silk Industry of India," p. 25.

ANTHERÆA PEROTTETI.

This is described by Mr. Geoghegan as producing a strong, wiry, and brilliant silk, but requires carding. The larvæ feed, in captivity, on the *Odina wodier* (Roxb.). "Undergoes four moults, and yields four crops a year." Fishing lines of this silk are said to be made in Dinapoor.

ANTHERÆA ROYLEI

Is described by the same author as being found at Darjeeling, and in the Himalayas from Kumaon to the Punjaub, and feeds on *Quercus incana*. The silk is good, but not abundant, and the insect can be domesticated. Yields two or three crops a year.

TUSSER SILK.

I now come to the principal subject of my paper, the Tasar silk, called also Tusser, Tusseh, Tussah, Tussore. It is the product of the larvæ of the moth *Antheræa paphia*, of Linnæus. It is known by the following synonyms*:—

Phalæna, Atticus paphia (Linnæus).
Bombyx paphia (Fabricius).
Phalæna paphia (Roxburgh).
Saturnia paphia (Helfer).
Phalæna, Attacus mylitta (Drury).
Bombyx mylitta (Fabricius).
Antheræa mylitta (Hübner).
Attacus mylitta (Blanchard).
Saturnia mylitta (Westwood).
Bughy silkworm, moth of the Burbhoon hills.
Kolisurra silkworm, moth of the Mahrattas.

There is but little doubt that this silk has been utilised for many centuries, both in India and China, but I have not been able to find any account of its ancient history.

For the history and other particulars of Tusser silk I am glad to acknowledge my indebtedness to the report of Mr. Geoghegan. He attributes the derivation of the word Tusser to *tusuru*, the Hindostani for shuttle, and states this caterpillar to be the most widely distributed, as well as the most important, of the wild silk producers of India.

One of the earliest notices of this insect, or of a species very nearly related to it, is given by the venerable Rumphius, who was born at Hanau in 1657, in his "Herbarium Amboinense" (dedicated by him to the East India Company), vol. III., p. 113, pl. 75, he discovered the larvæ in Amboina feeding on the *Mangium caseolari rubrum* (Rizophora caseolaris, Lim.), a plant of the order of Terebintaceæ."† He says:—

"When I had kept the cocoons for three weeks, a moth came out quite perfect, which was the most beautiful and largest I had ever seen, which biting away (the silk), showed its head, and at the same time drew out with it a little flock of yellow silk; this the moth performed at night. Its body, like all other moths, is a dirty yellow colour, and in length two joints of a finger; it has two downy horns on its head, of a golden hue, and four large wings, of which the two largest are about an inch long and of a golden colour, but a purple line runs through them transversly, and every wing has, as it were, in its middle a window-like eye, which is surrounded by a purple circle, and, as it were, of the transparency of glass."

The larvæ, when fully grown, are about four inches in length; they have twelve joints or articulations, besides their extremities; their colour is green, resembling the leaves on which they feed; and they are marked with reddish spots, and a reddish-yellow band running lengthways. They feed on several plants:—

Rhizophora ealceolaris (Linn).
Terminalia alata glabra (Assum tree).
Terminalia tomentosa (the saj tree).
Terminalia catappa (country almond tree).
Tectona grandis (teak tree).
Zizyphus jujuba (ber tree).
Shorea robusta (sal tree).
Bombax heptaphyllum (Semul).
Careya sphærica.
Pentaptera tomentosa.
Pentaptera glabra.
Ricinus communis (castor-oil plant).
Cassia lanceolata.

In six weeks from the time they are hatched they begin to spin their cocoons, which they most curiously suspend from the branches of the trees, by constructing a thick, hard cord or pedicle of silky matter, which is made to grasp the branches, as seen in these specimens.

Tusser silk is found, as you will see by the map, over nearly the whole of India.

In the Central Provinces, Mr. Geoghegan says, Tusser is utilised in Raipose, Bilaspore, Sumbulpore, the Upper Godavery, Chanda, Bhundora, Nagpore, Balaghab, Seonee, Chindwara, Betool, and Nursinghpore. Sumbulpore is said to yield 3,500 seers (7,000 lbs.) of silk; Raipori, 6,0000 (12,000lbs.); Bilaspore 900 (1,800lbs.); and Chanda, 22,500 (45,000 lbs.). The silk is woven and used in the provinces in mixed fabrics of cotton woof and Tusser weft. But, at any rate, in some districts, muktahs, garments worn by Brahmins after bathing, cholees, women's bodices, and doputtas and dorwas, seem to be made of pure Tusser silk.

Captain Brooke* says:—

"In Seonee a regularly organised and thoroughly understood industry, from the rearing of the insects to the weaving of silk into cloth, with all its accompanying machinery of trade guilds, money lenders, &c. This state of things is, in my opinion, no disadvantage; for, in place of having to contend with the difficulties which, in India, always surround the introduction of anything new or unknown, the demand is all that is necessary to stimulate production to any extent required. Nor is this a figure of speech, for the natural food of the Tussar worm is the leaves of the saj, lendeya, and dhowra trees, all of which are found in every part of this district, and are, I believe, common to the whole of Gondwana. These trees are, besides, propagated with facility, and, as far as the requirement of the silk insect goes, are of rapid growth; hence, if the silk became more known and better valued, and the profits sufficiently attractive, we might witness a development of the culture similar in kind to that which has of late years taken place in the ease of cotton. Supposing, then, a demand to spring up, I am of opinion that the supply would, in a very short time, amply meet it. The nucleus of no inconsiderable trade now exists, and only awaits the stimulus of high prices. The primary question, whether the product is, or may become, of such value as to occasion a large demand, is one, perhaps, that more nearly concerns traders than Indian administrations; still, so convinced am I of the value and beauty of the fabric that can be woven from well-reeled Tasar, that I would venture to strongly urge Government action in introducing it to the markets of Europe."

* Horsfield and Moore's Catalogue of Lepidopterous Insects, p. 385.
† *Ibid*, pp. 386-7.

* "Geoghegan, Silk Industry of India," p. 109.

The worms require protection from birds and ants, which are their greatest enemies. The first cocoons are made in August, and are sold, after the moth has escaped, to the silk dealers at 4 to 8 pice (1½d. to 3d.) the hundred. The unpierced cocoons are only sold to rearers as seed, at 1·8 rupees to 2 rupees (3s. to 4s.) per hundred.

Captain Brooke says, "In Chanda and Bilaspoor, Central Provinces, the rearing of the worms is attended by many ceremonial observances, which begin when the insect leaves the egg, and are not discontinued until the cocoons are gathered and taken to the rearer's house. During the feeding of the worm, the Dheemurs lead lives of the strictest abstinence. None of the sex are allowed within a considerable distance of the trees upon which the worms are feeding, and if by chance a woman or impure man passes near the feeding grounds, the trees and worms are sprinkled in the name of Iogni (an incantation of the the god Mahades, whom the worms are supposed to represent) with water taken, if procurable, from a running stream, and in which tulsi leaves have been steeped. During the same period the Dheemurs carefully abstain from flesh, fish, or haldi as their food, nor do they cut their hair or shave, and carefully deny themselves all ablution. When the cocoons are formed, they collect into a heap, and a goat, pig, or fowl is sacrificed to Mahadee in his form Iogni, the blood is sprinkled over the cocoons, and, after a bout of liquor, are taken home. On the third day following, the Dheemurs shave and resume their normal condition."*

The caterpillars moult five times, at intervals of from five to eight days. When first hatched they weigh but ⅒th of a grain, and are about ¼ inch long; but at the end of their larval existence, which is from forty to forty-five days, they have attained a size of seven inches long, one inch in diameter, and weigh about 370 grains. They then begin to spin their cocoons, which are, as you see, of an egg shape, and silvery drab in colour. The silk is all regularly deposited in a compact manner, resembling in thickness and substance the shell of an egg.

The cocoons vary much in size. The largest I have seen are from Sambulpoor, and are two inches long and 1¼ inches in diameter, whilst smaller ones are not more than 1⅛ inches long and ⅝ inch in diameter. The weight of the large cocoons is, without the pupa and supporting pedicle, 28 grains; the smaller ones 8 grains. I have here an unbroken double thread reeled for me, from one cocooon, by Mr. H. Meyer, of Milan. It weighs 12 grains, and measures 1,332 yards, or a little more than three-quarters of a mile.

Mr. Coussmaker remarks† :—

"As a rule, there are certainly two crops in the year; the moths of the first batch come out in about four or six weeks after the first lot of worms (which come out at the commencement of the rains) have spun; those of the second batch remain quiescent until the rains begin again, that is to say, until May. As this entails the chrysalis remaining in the cocoon as long as eight months, exposed to the hottest sun and occasional thunderstorms, the cocoon had need to be made of a hard impenetrable material; so indestructible is it that Bheels and other tribes, which live in the jungles, use the cocoon as an extinguisher to the bamboo tube in which they keep the "falita" or cotton-rope tinder, used by them for lighting their tobacco, and the slow matches of their matchlocks. The cocoon is also cut into a long spiral band, and used for binding the barrel of the matchlock to the stock, being, as the natives say, unaffected either by water or fire. The cocoon consists of two kinds of silk; what it first spins is reddish, and of this the pedicle and outside network is made. This silk consists of threads of different lengths, but the rest is generally unbroken from beginning to end. . . . After the caterpillar has spun a layer of silk thick enough to conceal itself, it discharges some kind of gum or cement, thick and white, like plaster of Paris, and then, with its muscular action, it causes the gum to thoroughly permeate the whole cocoon and solidify the wall. In this manner it goes on, spinning layer after layer of loops, and cementing them all together until the whole of its silk is exhausted, and the wall of the cocoon becomes so hard, that it requires a sharp penknife to cut through it. The ring at the end of the pedicle, which has been spun round the twig, is a most necessary provision of nature, for it often happens that either the caterpillar has been unable to attach its cocoon to a leaf, or that, during the long time the cocoon remains unburst in the tree, the leaf or leaves to which the cocoon was at first attached become separated from it, and then the cocoon hangs suspended to the twig like a berry."

After eight or nine months in the pupa state, a moist spot is observed at one end of the cocoon. The moth is now about to emerge both from its pupa shell and from the cocoon. It secretes an acid fluid, which softens the cement of the cocoon, and enables it to separate the fibres sufficiently to allow its creeping out, it being, no doubt, assisted in this by its short pointed spines. The head of the moth first appearing with its antennæ, broad in the male, and narrow in the female, thus enabling the observer to note the sex, and to put them in pairs. The male moth generally flies away, the night of his exit from the cocoon after his wings become extended and dried. The female rarely does, but during the first three days of her existence she lays her eggs, which hatch in about twelve days afterwards. The new life of the moth does not extend to more than eleven days. As you will see from the specimens in the case, the moth is a fine and handsome insect, measuring across the wings about six inches in the male, and about five inches in the female. You will notice the similar vitreous and transparent wing spots to those of the Atlas moth. These spots are regarded with superstitious reverence by the natives, who see in them a resemblance to the chakra or discus of the god Vishnu, and are therefore induced to consider the moth a sacred insect.*

The latest report on Tusser culture is one from Major Coussmaker, dated Jangaon, Ahmednagar, on the 10th of January of the present year.

At Poonah he has established a breeding establishment, and has planted many young trees for feeding the worm. He says it thrives well on *Lagerstrœmia indica*, an ornamental shrub fairly abundant in the cantonment of Poonah. He has changed his plan of feeding them on cut twigs brought to them in captivity, and allows them, carefully watched, to feed in the open air on the growing shrubs. This was an evident change for the better; the larvæ moulted in four to five days instead of five to eight days; they spun their cocoons in 28 to 35 days instead of from 40 to 50 days, and the moths emerged from the cocoons in

* Captain Brooke, as quoted in "Geoghegan, Silk Industry of India," p. 110.

† The Tusser silkworm, p. 9, 1873.

* Geoghegan.

27 to 30 days, their eggs proving more fertile than under the former plan. He fed them also on *Carissa carandus*, and they throve still better on this; but the *Lagerstrœmia*, after having all its leaves eaten off, being cut off and repotted, was in thick leaf again in a fortnight, and was ever sprouting, whilst the *carissa* did not sprout again after having been once denuded.

For the next season's experiments, Major Coussmaker has planted between 700 and 800 plants of the following species, *Lagerstrœmia indica*, *Lagerstrœmia parviflora*, *Conocarpus latifolia*, *Carissa carandas*, *Zizyphus jujuba*, and *Pentaptera tomentosa*, so that we may look forward with a large degree of interest to the result of so practical an experiment to domesticate this interesting silk producer in the Deccan.

Capt. Brooke says*:—

"In Chanda and Sunboolpoor, Central Provinces, when the cocoon crop is gathered, koshtas, a weaving caste, visit the villages and buy them from the rearers. Then are then, as soon as practicable, boiled in a lye made from the ashes of Jungni stalks, a plant grown for the oil expressed from its seed. This process effectually kills the chrysalis, at the same time dissolving the mucilage of the cocoon. The cocoons are then stored for use. The method of reeling is primitive in the extreme, and to its imperfections I solely attribute the scant attention this valuable and very beautiful silk has hitherto received. A description of the process is as follows:—The spinner, always a woman, sits on the ground; on her left is an earthen vessel, with a thickish rim, about 6 in. in diameter and 3 in. deep. The saucer is three parts filled with a mixture of potash and ashes, patted down to a level surface, and kept damp with water. Upon this, the cocoons to be spun are placed, the outer portion, of inferior and nearly useless silk, having been first removed. The thread in ordinary use amongst the weavers is spun from seven cocoons; these are all placed at the same time in the earthen saucer, a filament is then taken up from each cocoon, and, being brought together, are rolled between the hand and left thigh of the spinner, which are kept damp by an acid solution of tamarind and water."

In Bengal, the cocoons are put into boiling water to kill the pupæ; in some districts, when intended for sale, they are put in boiling water and dried in the sun. In the Nizam's country, the cocoons are loaded with dhobee's earth and alkaline ashes to make the reel. In the Midnapoor district, they are boiled in cow-dung and reeled by hand.

Capt. Brook says that, in Seonee, the pierced cocoons are wound, and that no koshtee rejects a cocoon simply because the moth has eaten its way through it. He has fallen into an error as to the moth's mode of exit from its cocoon. It separates the fibres with its legs and wing spine, and so creeps out. It has neither teeth nor mouth proper.

Each species of silkworm has two stores of silk, one on each side of the alimentary canal, and below its mouth it has two so-called spinnarets or orifices, through which the silk issues simultaneously in fine parallel filaments. As the silk is drawn out of the stores, the worm coats it with a varnish technically called gum, which contains a brownish yellow colouring matter.

The Tusser worm, in spinning his cocoon, takes short sweeps of his head from side to side, depositing the silk very closely in parallel fibres as he does so. It has been thought that the worm twists the silk as it exudes it, but this is not the case. Besides the gum which coats the silk, the worm secretes at intervals a cementing fluid, which it kneads by an expanding motion of its body through the whole cocoon to consolidate and harden it. This cement gives to the cocoon its drab colour.

There is a striking peculiarity about the fibre of Tusser silk. I have carefully and thoroughly examined it many times under the microscope, and find undoubtedly that the fibre is flat and not round, like mulberry silk.

There is no doubt that it is to this property that Tusser silk owes its glassy or vitreous look, reflecting a little glare of light from the angle of incidence on its flat surface, whilst the mulberry silk fibre, being round, reflects the light equally in all directions.

By some this property is considered a drawback, but by the time the fibre has become modified, and the flatness diffused in the loom, I think the lustre of the cloth is enhanced by it.

This tape-like appearance gives the fibre this disadvantage, that it is less homogeneous than the round fibre of the mulberry silk, and I find an undoubted tendency in it to split up into smaller fibrets, thus causing the silk to swell out when subjected to severe dyeing processes, particularly the bleaching one of recent date, thus giving a substantial and important reason why its coloured cements should be removed by gentle action.

The fibrets have a distinct structure, upwards of twenty in number, and seem compactly laid together, showing the striated longitudinal appearance of the fibre under the microscope. I dare say it is this fibrous compound structure, absent, as you see, in the mulberry fibre, which is an element in its dye-resisting power. I found permanganate of potash to be the best agent to separate these fibrets.

TUSSER.

The diameter, from edge to edge, of a single flat fibre of Tusser silk from the outer part of the cocoon, averages $\frac{1}{770}$ part of an inch, and from deeper in the substance of the cocoon $\frac{1}{710}$ of an inch, but the external fibres are much more variable than the internal. The thickness from side to side side is $\frac{1}{1900}$ of an inch. The outside fibres are capable of supporting, without breaking, an average weight of seven drams, and the inner eight drams, whilst the usual amount of tension in all the fibres is one inch to the foot. The fibres, like all other silk fibres, are laid in the cocoon by the silkworm in pairs, united by their edges, and not by their flat surfaces.

All the *Saturniidæ* fibres I have examined are more or less fibrous and flat, except the English species *Saturnia carpini*, or Emperor moth, which, in North Staffordshire, spins a beautiful cocoon in the heather of our moorlands. My son has drawn for me an enlarged microscopic appearance of this silk, which shows its transparent and fibretless nature; and also, what is very curious, that the fibres are round, except where they come in contact, when they become flat, no doubt from pressure. This apparent exception to the *Saturniidæ* depositing flat fibres, and the *Bombycidæ* round ones, which I had established, possibly points to the secretion of the sericene in the different species varying in fluidity, that of the *Saturniidæ* being excreted in a more fluid state than that of the

* Geoghegan, "Silk Industry of India," p. 111.

Bombycidæ. There may also be a difference in the structure of their seripositors; but this I have not had an opportunity of investigating.

I am glad to state, the other diagrams were prepared for me by Mr. Rider, a pupil of the Leek Art Class. The maps, showing the wild silk districts, were done by Mr. Alfred Moore, of Leek, and I have been much helped in the microscopic work by my assistant, Mr. Rigby, and I must not omit to mention the assistance rendered me by my printing staff.

It is a fallacy, held by some entomologists, that the worm twists the two threads together as it forms them at the orifice of its spinnarets, in all species, both *Bombycidæ* and *Saturniidæ*. The two threads are simply laid side by side, as you see in the diagrams. It would be impossible to twist the two threads without the worm itself revolving continuously with the emission of the silk, or for it to have spinning wheels at the secreting orifice. I propose, therefore, to change the word spinnaret, which conveys an inaccurate impression, and substitute for it seripositor.

Leaving now the more beaten track of the natural history side of the question, I come to speak of its merchantable and art side. Finding, many years ago, that Tusser silk opposed a resistance in no ordinary degree to tinctorial matter, I took an interest in the subject with a view of overcoming this resistance. In its small affinity, ordinarily speaking, for colouring matter, it ranks with the vegetable fibres of cotton and flax, and whilst, in many processes, it would come out scarcely tinted, the mulberry-bred silk would be found to have seized the colour with avidity. It, however, takes the aniline dyes, under certain conditions, moderately well. At that time, and for some years previously, little Tusser silk had passed through the dye-houses. About forty years ago an attempt was made to introduce it in Macclesfield for sewing silk for black, but, on account of its irregular way of taking the dye, it was abandoned. Mr. David Clarke, of Macclesfield, at that time, with his father, Mr. Jeremiah Clarke, were much interested in bringing it to the front; but, as Mr. D. Clarke informs me, the second parcel not coming from the dyer in a saleable state, a costly trial took place at Chester to determine whether the blame lay with the dyer or the silk. I believe it was decided in favour of the manufacturer, and against the dyer, who, unfortunately for him, had succeeded in dyeing the sample parcel successfully. However, the result was that little or no Tusser silk has been used for sewing purposes from that day to this. About twelve years ago I made many experiments in dyeing this silk, and had the satisfaction of seeing my way to further utilisation and improvement. In 1873, the firm of which I am senior partner, consisting of my brother and myself, exhibited, at the International Exhibition at South Kensington, the result of progress up to that time, in a series of black and coloured silks, which were in advance of any similar effort, either English or Continental, as far as my observations or knowledge extended, and they attracted a good deal of attention and led to a further utilisation of Tusser silk, then a drag in the market, except for dress silks for women and girls in the undyed and pleasing shade natural to it, which is fawn colour.

The development up to that time had been that this silk could be dyed into any middle or dark shade of drab, slate, brown, green, violet, or dark red, whilst, to pale shades of blues, pinks, cerise, scarlet, and others, the dark natural ground colour of the silk interposed an insuperable barrier, as sulphur, or any then known bleaching agent, could not reduce the silk to a whiter state. The *desideratum* of pale shades led our quick French neighbours to study the composition of the brown colouring matter, and to find a solvent for it. The credit of this achievement must be awarded to M. Tessié du Motay, who was led to try permanganate of potash, which was at that time attracting much attention on account of its great oxidising power on organic matter. He found the browny colorant yielded to this agent. Unfortunately, the oxidising action being too violent, the fibre of the silk as well as its coloration was affected, and the silk was tendered by the time it became white enough for dyeing into pale colours, so much as to render it useless. However, a secret had been discovered, and it was this, that oxygen, under certain combining conditions, united with the colouring matter, which then became separated from the silk. The object now was to apply the oxygen under gentler conditions. This M. Tessié du Motay again succeeded in doing, and in a very ingenious way. He brought into contact with the silk an insoluble body, which, on contact, should yield up an atom of oxygen in the nascent form which should gently unite with the fawn-coloured matter of the silk without attacking the fibre. This, although a rough method, solved the difficulty, and the silk, originally of the colour of this sample, can now be bleached in this way to that of the sample I show you, which is of sufficiently pale a ground to admit of its being dyed into any pale colour except white. The substance he found to comply with the required condition is binoxide of barium. Unfortunately, the process is too expensive, and prevents an extensive utilisation of Tusser silk, but there is a probability of the principle being shortly applied by other methods, which will be at the same time cheaper and more within the legitimate sphere of dyehouse technical operation than that of M. Tessié du Motay, I mean, whereby the nascent oxygen shall be presented to the silk in the vat from a solution, instead of from a solid, as at present.

In 1874 I had the honour to receive a communication from Sir Louis Mallet, Under Secretary of State for India, asking me to communicate, "for the information of the Government of India, any details I might be in a position to furnish on the subject of dyeing the wild silk produced by the Tusser worm."

On my report being received, I was requested to make a full investigation of the subject, which divided itself naturally into two heads, a consideration of the silk, and of tinctorial matters. For the first, I found the raw silk as it comes into this country to be prepared by the natives of India and China in such a rude and filthy state as to interpose unnecessary obstacles to its taking the dyes. I felt sure that cleaner and more skilful methods of reeling and preparing the silk for the market, would be accompanied by less resistance to tinctorial matter, as well as furnishing a greatly improved

quality. At my request, orders were issued for the collection in the different provinces of India of a complete assortment of native dyestuffs as well as a supply of Tusser silk.

In recommending the Government of India to have the natives taught the dyeing of their wild silks with dyestuffs indigenous to India, I had two motives, one to prevent the native art of India being tampered with by the introduction of European fugitive dyes and crude colours, and another that they could be made to utilise, what their country has ever been so rich in, the remarkable variety of native-grown dyestuffs which in other than wild silk fabrics, they have known probably for thousands of years so well how to use. To take dyestuffs to India must surely be carrying coals to Newcastle. I have since received an extensive and most interesting series of India dyestuffs and tanning materials, which I have at present under examination. I also received a quantity of Tusser cocoons, and, not being able to have them reeled in England, I was authorised to go to Italy to see if I could have them reeled there, and effect my hope for improvement in the manufacture. By the introduction of a friend, I obtained permission to visit one of the filatures in Piedmont, that of Messrs. Gaddum and Co. On arriving there I found an extensive mulberry silk reeling and throwing establishment, situated in a most beautiful valley, in one of the southern spurs of the Alps, about three hours' journey north of Turin.

On explaining my mission, and showing the wild cocoons, I was told there was not much chance of success, for they had several times tried them, and had found them difficult to soften, and impracticable to work; but knowing too well how natural is the tendency of mankind, in any new idea, to suggest objections rather than the means, I asked for permission to be allowed to try myself. The permission being generously granted, and every assistance kindly afforded me, I was taken to the reeling room, where about 100 young women were at work, with well-trained fingers, reeling the small Piedmont cocoons of *Bombyx mori*. The operation was interesting in the extreme, heightened as it was by their strange singing of old French songs, in a dialect not even understood by the Italians, a strange and all but forgotten tongue, which has to be learned by the mill-overlookers before they can communicate their instructions to them. I was told these girls were the descendants of Huguenot refugees, escaped probably from Provence to the Italian side of the Alps, at the Revocation of the Edict of Nantes, and that they still retained their patois and their folk lore; they worked hard for the few months of cocoon reeling, from five in the morning until eight at night, for a franc a day; after work dancing and singing for the hour before bed time in the most joyous way. Apartments are provided for them at the factory, and when the reeling season is over, they separate and return to their Alpine villages, to wait for the next season's work.

The operation of unwinding silk from the cocoon is as follows:—A number of cocoons are immersed in an iron pan, in water, nearly boiling, with a little alkali to soften them. A semi-rotating brush is placed over them, which quickly catches the exterior fibres of each cocoon, and the more readily enables the reeler to find the windable thread. They are then taken out and transferred to the reeler, who sits leaning over an iron pan of about 12 inches in diameter, in which she has a few cocoons in hot water, the found ends of several being in one hand. Four or six cocoons, as the case may be, are being simultaneously reeled into a single thread by the reel at her back which draws off over her head the cocoon threads, they dancing and turning in the water. When a thread breaks, or the cocoon is reeled, another is quickly presented from the lot in the other hand, the manipulation being one of great dexterity. Several years are required to attain proficiency, and it is not until the fifth to the seventh year that a reeler is entrusted with the most delicate reeling; the keeping of the size of the thread regular and free from rough places being the most important care.

It is this branch of the manufacture that in Tusser silk is so defectively treated in India, the reeling being done in some instances round the naked knee cap, but generally with this hand reel.

I took some of my wild cocoons, and, with much difficulty and patience, after several trials, succeeded in softening them by the aid of long-continued boiling in water, to which was added soap, potash, and glycerine. When soft enough, one of the most skilled girls was told off to reel them for me, and, after ridding the cocoons of the outer and coarser threads, she reeled the thread of four cocoons into one, almost without a break, much to her own delight and to the surprise of my friends and myself.

The next day, the resulting Tusser raw silk was taken to the throwing mill, and there made into Organzine and Tram, of such fineness as to surprise my friends, who said that they had no idea that Tusser silk could be made so fine, and that they should think seriously about sending a person to India to collect Tusser cocoons, that their workpeople might wind them after their mulberry crop had been finished.

The usual size—that is, thickness—of thread of Tusser raw silk of commerce is 152 to 255 deniers—that is, skeins of 1,000 yards long, weighing 9 to 15 drams. From some of the finer raw silk a size of 6 to 7 drams is obtained, but it is generally coarser. From the cocoons, the reeling of which I superintended, I obtained a size of 51 deniers, or three drams, per 1,000 yards, a sample of which I have the pleasure to show you.

Here are samples of Tusser raw and thrown silk I have received from M. H. Meyer, of Milan, obtained from cocoons I sent him. The size of the raw is 23-27 deniers, or $1\frac{1}{2}$ drams per 1,000 yards; the Organzine and Tram are 50-55 deniers, or 3 drams. He found some of my cocoons very difficult to reel, no doubt owing to their age, and to not having been reeled before weather exposure. Fourteen pounds and a-half yielded one pound of raw silk. He informs me that some cocoons he has just purshased in Marseilles are larger in size than those I sent him; they are darker in colour, but reel much better. He is obtaining from ten pounds of them one pound of raw silk.

Even a finer thread might be obtained, but as the fibre is only the $\frac{1}{710}$th part of an inch, or three times as thick as ordinary silk, I think 51 deniers is a good and practicable limit when native reelers can have proper appliances, and be taught to be as handy as the reelers of Italy or the south of France. I dare say some of my hearers may remember the im-

provements which took place in reeling the mulberry silks of Bengal and Brutia, when superior skill and machinery were introduced, a good many years ago. Before that time Bengal silks were held in very low estimation, and were very difficult to work, but after the introduction of better appliances, Bengal silk was shown to be as capable of refinement as any other; and Brutia silk now commands, by its superior quality, the highest price in the market; and I have no doubt that, in degree, equal success lies waiting for the Tusser silk industry.

I trust I may point to this manufacturing development and great improvement with pardonable pride, more especially as I am not a manufacturer, and could scarcely expect to find untrodden ground in a domain distinct from, although allied to my own.

The new reeled silk is much lighter in colour, as you see, than native reeled, and has very much more lustre; in fact, it is the most lustrous, in the undyed state of all silks, and possesses greater strength and tension. I found, what I expected to find, that the silk thus reeled dyes much more easily, more shades and lighter ones can be dyed upon it than native reeled, it has no disagreeable smell, and only loses two ounces per pound in being cleaned for dyeing, where native reeled Tusser loses in some cases as much as six to seven ounces per pound, and never less than four to five ounces. It is as clean, to use a technical term, which means free from slubs and irregularities of thread, as ordinary silk. The cost of reeling new and good cocoons, and manufacturing them into Organzine and Tram, is about seven shillings per pound, and it is certain to make its way in many fabrics where extreme fineness is not required, and for a variety of purposes in passmenterie, trimmings, braids, scarves, broad and narrow goods. It is beginning to be largely used for these purposes in France. Its price has lately risen, whilst that of other silks has either remained stationary, or actually depreciated.

I have urged on the Government of India the importance of introducing to the natives of India the European modes of reeling cocoons, and some time ago drew their attention to an invention which simplifies and economises this operation.

Mr. Mackenzie, engineer, of Milan, has introduced a Milan house of filateurs, who have invented and patented another mode of reeling, by which skilled labour is dispensed with. If this machine is pronounced by experts to be a success, there is no reason why cocoon reeling should not be carried on in any village home, as flax spinning was formerly.

M. David, the largest ribbon manufacturer in St. Etienne, seeing this improved manufacture and dyeing in the Indian Section of the Paris Exhibition, where they were first displayed, offered to buy all the cocoons produced in India, if the price would not be more than one franc per kilogramme, a price which Dr. Birdwood assures me is reasonable. He has applied to the India Government for 2,000 kilogrammes of cocoons for experiments at his own cost. It would be a very good thing for a trade to spring up in Tusser cocoons. The natives could easily be encouraged to breed a larger supply, whilst improvements in reeling would require time, and would meet with obstacles of race, religion, and habit difficult to overcome; also the enterprise in this direction would have to be purely private and mercantile, as I think the Government of India would not enter into commercial undertakings, but would probably, and certainly ought to, give most strenuous encouragement and help to stimulate the further spread of this most interesting industry.

I was requested by Dr. Birdwood last year to exhibit the developments of which Tusser silk was capable, in the Indian Section of the Paris Exhibition. Sir P. Cunliffe Owen entered most warmly into the idea, and took the greatest interest in it throughout, giving me all the encouragement and help required to make it worthy of being represented side by side with the beautiful objects in which India had determined to assert herself. In no exhibition before had India been shown in a manner so worthy of the gorgeous East. It was the India of the artist which asserted itself at Paris—the old historic land, from which art manufactures in brocades, printed calicoes, jewellery, ivory carving, and pottery may still draw their highest aspirations. Neither had ever before been so much done for the promotion of Indian commerce. These results are entirely due to Sir P. Cunliffe Owen, and to one who so ably assisted him, Mr. P. C. Clarke.

In the wild silk exhibits which I was entrusted to bring together in this Section, not only were the improvements shown in manufacturing and dyeing, to which I have alluded, but another and more decorative phase, and one developed, so far as I can gather, for the first time in the history of either the East or the West—that of printing. It had struck me that fabrics made of Tusser silk, either of native or home manufacture, would be susceptible of much enrichment if they could be printed upon. After many fruitless attempts, I at last succeeded, and since that time I have had the satisfaction of succeeding in applying and fixing a much wider range of colours.

Thinking that designs of an Eastern type were naturally the most applicable to cloths of this wild silk, I have obtained, by the courtesy of Dr. Forbes Watson, the loan of a large series of wood printing blocks, of native design and workmanship, from the India Museum. I have used them for printing nearly all the illustrations of my lecture, and have placed a few on the table, to show how beautifully they are cut. In England the finer details would be in copper, but in these the hardest wood has been chosen and most skillfully cut. To complete the consistency, I have adhered to the use of native Indian colours and colouring matters. You will notice the deep rich red of the India print in madder or munjeet, the good toned and permanent indigo shades, as well as a variety of other well-known native dyes. The designs on these blocks are extremely interesting, and if I had time to exhibit the whole series of the impressions I have taken from them, I am sure you would agree with me how they abound in originality and beautiful drawing. If from this we are led to think generally of the native art of India, we may justly feel some sorrow and regret that our influence there does not tend to perpetuate it, and regret with Dr. Birdwood, as he so well describes in his handbook, that it daily deteriorates. If it were not that Sir Cunliffe Owen is sitting so near to me, I might be led to suggest whether we could

not try the experiment of turning the tables somewhat, and that, if we must send our art masters to India, we might at least import some from there to try to bring us into better ways.

Truly our credentials to teach an artistic people are in a sad condition; if we take but architecture for example, we are but copyists. Imitation seems to be the evil genius of our time, and even what little originality we have to be thankful for, in is preyed upon by an unprincipled selfishness and decorative or structural art, is no sooner born than it rascality, which, in the greed for gain in such matters, sees no distinction between *meum* and *tuum*; whilst, on the other hand, so strong is the existing jealousy to protect that which should benefit all, that we may scarcely with safety look over our neighbour's palings to see how green his lawn is.

I would call attention to the sweetness with which the colours repose on the natural and unbleached ground of the cloth, as well as the greater sharpness and depth of those printed on bleached grounds.

Many of my examples are painted in print colours, on outline printed designs, an ancient and most interesting mode of decorating cloth, which I have revived.

I think you will agree with me that the material so decorated is beautifully suited to wall hangings, curtains, coverlits, and all kinds of furniture work, and whilst not having quite the brilliancy of the mulberry silk in its printed state, it has a richer and softer surface than those of cretonnes or challis, whilst its lasting qualities are superior to those of any other material.

Messrs. Durant, of London, have kindly informed me that Tusser raw silk comes from China, and they believe the large shipments of two years ago were principally owing to the famine in the districts of productions. Scarcely a bale, they say, has come forward during the present season, nor do they expect any at the present prices. The present price of Tusser raw silk in London is 4s. 6d. per lb. The stock in London is China Tussore. It is collected in the district of Chefoo and shipped from Shanghai. The price of Indian Tussore cloth is about 2s. per yard, 34 inches wide.

There is a very large quantity of China Tusser cloth exported from London to the Colonies. An immense trade would be developed in India if better qualities were woven there.

TUSSER.

The following table shows the state of the London market in Tusser silk for the last few years:—

Year.	Stock, Jan. 1st.	Imported.	Consumed.
	Bales.	Bales.	Bales.
1874	662	none.	168
1875	494	none.	319
1876	175	427	174
1877	428	1,037	284
1878	1,181	837	736
1879	1,282	..	145

The stock, February 1st, was 1,137 bales, with a consumption for January of 145 bales. Should the demand continue, at this rate the supply would be insufficient for the year if no more comes in.

The average consumption for the four years ending 1877 was 238 bales, whilst the consumption for 1878, the year that attention was drawn to it by the Paris exhibits, more than trebled itself, the purchases being 736 bales for that year.

The following table shows preseut prices of silks in the London market (April 18th, 1879):—

	s.	d.
China raw Tsatlee, No. 4, per lb.	15	6
Canton ,, No. 1 ,, ...	13	6
,, ,, No. 4 ,, ...	11	6
Japan ,, Marbush, No. $2\frac{1}{2}$,, ...	16	0
Italian Organzine	25	0
Bengal raw.........................	14	6
Brutia ,, ...	23	0
Tusser ,, ...	4	6

The great improvements made in this country and on the Continent of late years in carding and spinning machinery, have enabled manufacturers to utilise all the silk that could not be reeled, such as pierced cocoons and all kinds of waste silk.

Mr. Clayton has been kind enough to lend me, for my lecture, illustrations of this useful phase of manufacture, specimens of spun Tusser silk in each stage of manufacture, from the first carding or dressing operations to such perfected fabrics as you see before you in cloths of varied design and substance, yarns for weaving and sowing, and shawls in plain and printed states.

There is now a great demand for Tusser and other wild silk waste, and England possesses more than sufficient machinery to spin all that can be imported.

Another form for the use of Tusser silk is the manufacture of embroidery silks, and their application to cloth by the needle. I have had manufactured a few silks, which have been arranged by my wife for illustration this evening. She has also worked a few pieces of Tusser cloth in these silks in various designs. The larger piece of embroidery, which is unfinished, is a trial piece. Mrs. Wardle began to work first with untwisted silk, which, as may be observed at the left corner of the work, has a fluffy appearance; therefore, I recommend for embroidery purposes a slightly twisted silk, which I think will be an improvement on crewels, and possibly filozelles, and so prove a useful industry.

DISCUSSION.

Dr. Birdwood said:—Ptolemy was the first to use the word *Serice* for China, or, rather, the northern part of it, known later as Cathay; and the word is derived from the Chinese name of the silkworm, *see*, in Corean *sir*, whence the Greek Σήρ, the silkworm; Σῆρες, the people furnishing silk. The Latin, *sericum*, had been traced direct to the Mongol, *sirkeh;* and the *serikoth* of Isaiah, xix. 9, has been supposed to be silk. If the latter identification is correct, the trade in silk between the East and West went back to the remotest antiquity. But there is no undoubted proof of a knowledge of silk in Europe, until the time of Alexander. Aristotle certainly describes the silkworm, and the Greeks of Alexander's expedition must have seen both Chinese and Indian silks in India, and Tusseh cocoons. When Chinese silks and the manufacture of Tusseh silk were first introduced into India is also an obscure question,

In the *Ramayana*, silks are mentioned among the presents made to Sita, the bride of Rama; but whether these were of Chinese or native manufacture cannot be determined. In the *Mahabharata* it is said that the "Chinas, Hunas, Kashas, and Cauchas, who lived in the mountains," brought as tribute to Yudhestra "silk and silkworms." If the "Chinas" here really were Chinese the question would be settled. But I believe Colonel Yule has somewhere stated that the "Chinas" of the *Mahabharata* were some tribe of the North-Western Himalayas, near to the Dards; and so everything is left in obscurity as to the first introduction of Chinese silk into India. It is not even known whether the Arabs, on their first arrival in India, found the silk manufacture already going on there, or introduced it themselves. Pliny's account of the silkworm is taken from Aristotle, but he knew Chinese silk well, and he also tells us that in his time the wild silk of the Tigris valley was woven into gauze. Pausanias, about 100 years later, also describes the silkworm; and the allusions to Chinese silk by the Roman poets from the time of Augustus are too numerous to cite; but it is clear that before the time of Julius Cæsar silk was but little known in Europe. Procopius, about A.D. 550, tells the story of the introduction of the silkworms eggs into Constantinople in the reign of Justinian, and how the culture of silkworms and the manufacture of silk spread from that time all over Southern Europe is a thricetold tale. Mr. Wardle has been so good as to refer to my report of 1858, on Tusseh. I would wish to state that the first person to suggest the utilisation of Tusseh cocoons in Bombay, was the late Mr. Edwin Heycock. A meeting was held in Bombay, in 1857, to found the Victoria and Albert Museum, and Mr. Heycock, in pointing out how useful it would be in bringing jungle products into public notice, instanced the waste of Tusseh cocoons in the Bombay Presidency, simply through the ignorance of merchants in Bombay of their existence. I reported the matter to Government, and a large quantity of cocoons were at once sent to this country, and inquiries made all over the Presidency, which elicited the fact that Tusseh cocoons were as abundant in Bombay as in Bengal. Afterwards, Major Coussmaker and Dr. McKenzie paid great attention to the matter, when, at last, the task of practically investigating the comparative commercial value of Tusseh silk was fortunately taken up by Mr. Wardle. His paper has scarcely done justice to his own labours in the matter. It is, perhaps, too encyclopœdiac, and at the same time, says too little of his own experiments and their practical results; and as I know more of Mr. Wardle's work than, perhaps, anyone else in the room, I doubly regret that I am under the necessity of having to leave at once. Briefly, Mr. Wardle has at last, after years of patient research, succeeded in spinning Tusseh silk as fine as the finest Chinese silk, and in giving to it every tincture which Chinese silk will receive. He has thus made it merchantable wherever silk is reeled, spun, woven, dyed, printed, or used for personal or household adornment. Here is the prospect of a great gain for India, and Mr. Wardle deserves for it the grateful acknowledgement of everyone interested in the welfare of India. Sir Philip Cunliffe Owen said he regretted not having put Mr. Wardle's exhibits more forward at Paris last year; but I am an eye-witness to the fact that Sir Philip did everything in his power to promote the deep interest of India in Mr. Wardle's work. Universal attention was drawn to it in Paris, and if, henceforth, Tusseh becomes a yearly growing article of export from India, the result will be almost as much due to Sir Philip Cunliffe Owen as to Mr. Wardle. I must add that I was perfectly astonished on entering the room, and seeing the samples of printed Tusseh—in Indian dyes, and stamped with Indian blocks—exhibited here to-night by Mr. Wardle. I could not have believed it possible for him to have made such progress in the short time since I saw his last tentative efforts; but while I congratulate him on the taste and ability in the dyer's art these beautiful fabrics show him to possess, I can not altogether wish him success in his imitation of Indian designs. Imitation is no more good for us than the natives of India, nor is it possible to welcome these efforts to take a manufacture out of their hands, simply because, being rulers in India, we are in a position to force their hands.

Mr. Francis Cobb said there was no doubt that the demand for this silk had increased recently, partly in consequence of a change in fashion. There had been a run on it by the French; and, owing to a change in the method of dyeing, almost every colour, even of pale rose, could now be dyed. How much was worked up in the fabrics which were supposed to be all genuine China silks, he believed it was impossible to say, especially those subject to heavy dyes. During the last two years, the demand in China for this Tusser silk for France had been so great, as to seriously interfere with the supply required for the country, which, as it was the cheap silk of the country, was very large. The French had now pretty well exhausted China, and hence one great cause of the anxiety which was noticed at the Exhibition; they were all aware that they were fast exhausting China, and turned with the greatest delight to the specimens received from India, showing that there was a new field open to them. He trusted, however, that the whole of the industry was not destined to find its way to France. Although they had made some rapid strides there, we had also been leading the way in this country, and but for the fact that they beat us in the cost of labour, he had no doubt that the Tusser industry would have developed itself to a greater extent here than in France. He might say that the *Attacus ricini* was a worm which was a good colonist—it might be taken to almost any of the colonies, and it would thrive. It fed on the castor-oil plant, which grew wild in most of our colonies. For instance, in South Africa, when land was cleared a castor-oil plant would immediately spring up. Mr. Wardle had shown how valuable that particular silk was, and it might be grown to a very large extent in the colonies. He did not believe that these Tusser silks, now that attention had been called to them, would ever go out of demand, and all that India or our colonies could send would find a ready sale for many years to come. The ailanthus, of which they had heard so much seven or eight years ago, and to which Lady Dorothy Neville devoted a great deal of attention, seemed to have failed, and the reason was that the labour expended upon it did not produce a result which would pay its cost. He doubted whether in such a country as this we could ever rear the ailanthus worm to a profit. When he was giving a great deal of attention to this matter some time ago, he remembered being informed that there were thousands and thousands of acres of trees in Assam which were infested, as it was termed, with these wild silkworms, and that they only required gathering. He presumed that was the Moonga which Mr. Wardle had spoken of. In the north of Ceylon again there was a large forest district of which very little was known, but there was a cocoon found which was open at the end, and the silk came up there and formed a loop. When that cocoon was treated with caustic soda, or potash, it became softened, so that it could be reeled pretty readily, but he had grave doubts whether reeling was ever worth the trouble and cost for any of these Tussers. Although Mr. Wardle had succeeded in producing very fine reeled silk in Italy, when that silk was completed and reeled it was not equal to China or Italian silk in the same condition, and he doubted whether it was a kind from which we should ever get any very fine results. He would rather adopt Dr. Birdwood's suggestion, and take the coarser manufactures of this silk, and trust to the play of light and shade to produce that rich appearance which he spoke

of. Mr. Wardle said the Tusser silk which came from China appeared to be better reeled, but the reason was that the Chinese reeled the cocoons at once, they did not wait until the chrysalis was killed by heat, and at that time it was more flexible, and had greater elasticity and brilliancy. This was a thing to be noted, and to be introduced into India, to secure the cocoons whilst the chrysalis was still in them, and thus to produce them in a condition in which the silk might be spun. No doubt M. David would be very glad to get a great deal of this silk for one franc per kilogramme, which Dr. Birdwood thought a reasonable offer; but he thought there would be no difficulty in selling it in this country for two shillings per kilogramme. He did not think that it was the price which stopped the supply, but, rather, that it was the French demand, which had pretty well cleared all the available silk from China, and that they would not send any more, except at a very enhanced price. With regard to the difficulty in dyeing, he believed that had been overcome by Mr. Wardle. He had been as yet unable to find out how it was done in France, and the last answer he got to his pertinacity was, that he was not likely to find out, as it was a trade secret. Still, he had hopes that Mr. Wardle, in his persevering manner, would eventually find this out for himself, and would be able to compete with the French, even in the most delicate light colours. The exhibit he had shown was the most remarkable he had ever seen, and the dyes were such as, a few years ago, he should have thought were impossible.

Mr. Davenport said Mr. Clayton, who had exhibited some of this Tusser silk at the Paris Exhibition, was present, and he hoped he would give them some information upon it.

Mr. Wardle said he wished to supply an accidental omission in his lecture, and that was with regard to the adaptability of Tusser silk for spinning. He had there some beautiful manufactures of spun Tusser silk, but unfortunately they had been so delayed by the railway, that they only arrived at the last moment after his lecture had gone to press. They had been kindly lent by Messrs. Clayton; Mr. Clayton was present, and he hoped would explain them.

Mr. Clayton said that some four or five years ago, a large shipment of Tusser waste came over here, and was lying about a long time in Lower Thames-street. From thence it was taken to Manchester, where it also lay for two or three years, as no one would look at it. He accidentally came across some samples, and determined to try some experiments. The first trial was so promising that he got further samples, and the result was that they showed some of the sliver to the firm of Sir Titus Salt and Co., with the idea that this silk could be mixed with brown mohair, which that firm were spinning at that time. They at once asked him not to mention it to anyone else, but to get a few skeins of sliver prepared, and to bespeak the whole parcel of this material. They got an order for 1,000 weight, but in working it up, Messrs. Salt discovered some hitch or defect in the spinning, and had to discontinue it for the purpose originally suggested. His firm had by this time the whole parcel on their hands, and therefore they had to endeavour to utilise it themselves. After repeated experiments they discovered the means of giving it spinning qualities, and they introduced it into the market in the shape of threads for various purposes. The trade had gradually grown, and 12 months ago they had got through the whole parcel of raw Tusser waste, which they found afterwards was all that was brought from China. After those threads and cloths were shown in the market and sold, they found the raw material came over very slowly, and at present there did not seem any prospect of further supplies. This led him to investigate the question of developing the trade from India. They had no longer any of this raw material coming from China. There was not a bale in London, and as far as he could learn not one on the way. The importance of this branch of Tusser industry would be apparent when it was remembered, as was stated, that in the reeling off the cocoon to obtain one pound of raw silk, ten pounds of waste was made. According to Mr. Wardle's statement, the larger portion of the Tusser cloths came from India, and he was rather at a loss to know what became of the enormous quantity of waste produced in making them, inasmuch as to his knowledge none had ever come to this country except a few pounds. It was, therefore, of great importance to those interested in Indian produce to get at the reason why this waste was not collected and brought to this country. Unless some was brought from India or elsewhere, the industry would die out for want of raw material.

Mr. A. Rogers said he had seen this very waste being spun in Messrs. Allen's mill, in Bombay. The cocoons were brought in large bales from the jungle just squeezed together, and flattened like a cotton bale. This waste they crushed, and teased it out into very nearly as fine sliver as was shown on the table; and he was perfectly astonished at the cloth made from this waste. He brought home some specimens, and gave them to the Manchester Chamber of Commerce, where, no doubt, they could be seen. Another curious fact which came under his notice was this. There was a man in Bombay, a barber, who made a most remarkable discovery, with regard to Tusser silk. He showed him the produce of silk which had been spun by a hybrid worm, produced between the common Indian Tusser worm, and what he said was the Japanese Yama-mai. Whether that was the case, he could not say, but he certainly showed him the two worms, which were about the size of his little finger, and he informed him that the silk produced was much freer from tannin than the indigenous Tusser found in the jungle. He showed him some specimens, and so far as he could judge, the hybrid silk was far superior to the other. Mr. Morris assured him that this hybrid would feed on the commonest trees in the country, particularly all trees of the fig tribe. If that were the case, and a superior kind of silk could be produced by hybridisation, one could see what an immense future would be open for production, and it would especially afford a means of employment for the mass of the people, especially women. In the higher classes the women were never allowed out a doors, and it would be an inestimable boon if they could be induced to amuse themselves by rearing worms and producing silk. Even in the years of famine, the trees on which the worms fed never failed, so that in such seasons of disaster the existence of this industry would be an immense benefit to the people.

Mr. R. F. Mackenzie, being called upon to describe his machine for reeling silk, which is now at the India Museum, said he had great confidence that it would work Tusser silk admirably. They tried a small experiment with some cocoons, and it had failed, but the failure was not due to any fault in the machinery, or in the softening process, but he discovered from Mr. Moore that the cocoons were 12 years old; consequently, the chrysalides inside had got decomposed, the air and water got inside the cocoons, and they would not float. Of course, if the cocoon was fresh it would not imbibe the water, and he had no doubt the silk could be reeled very finely, because one cocoon of Tusser would yield a thread which could be worked, and two or three threads would be equal to ten of ordinary Bengal silk. His machine was certainly more applicable to a Bengal cocoon than to any other, and the chief purpose in inventing it was to work these cocoons in large numbers. Of course it would work every other kind, but the advantage would not be so great. When there were ten cocoons going into one thread, as hand labour was depended upon to feed all those ten threads, it became a serious matter, because it took five or six years to become

an expert reeler. In India he did not think they were more expert or intelligent. The machine could be seen at work, on Mondays, Tuesdays, or Wednesdays, at the India Museum, on Indian silk. Hitherto, it had been applied to Italian silk, and had worked admirably. He must say that he was much indebted to the authorities at the India Museum, and to the Indian Government, for the assistance they had given him; and he thought they were all much indebted to the Government for attending to these matters, which, he thought, were quite as important as sending armies to conquer a country. To show how easily it could be worked, he might say that he asked Dr. Forbes Watson if he could procure an intelligent boy or girl to work it, and they were fortunate in getting an intelligent girl of 14. They gave her three hours' instruction, and then set her down to reel. She began with one thread and reeled two threads, which was sometimes equal to twenty cocoons. They were doing Italian cocoons, which were much more easily reeled, and about a week ago she reeled three threads with six cocoons each, and two threads of the Bengal cocoon with ten cocoons each, and he could safely say that the produce would compare with anything ever shown in the London market. They were now making arrangements to send out a staff to India and China to do the thing on an extensive scale. He believed that the Tusser cocoon could be reeled as fine as anything, and it required but few threads. It was true that the threads were flat, and that was a point which made it a little difficult. The only way he could account for that, if he might venture to do so, was from the fact that there was a great amount of woody matter in the Tusser cocoon, and very much less glutin, while there was a great deal of moisture, and no doubt the silk moth used the threads in a very wet state, and, in consequence of the great heat, it became very hard, and that must flatten the thread to a very great extent. Some time ago there was an idea of introducing cocoons and spinning and reeling them in this country, but it had not been carried out. In Asia Minor, however, and all over France and Italy, it was carried on largely, and he did not see why they should not be reared in England, or why the Indians should not be put in a position to reel from them and to send the organzine and tram to the English market.

Mr. A. Rogers said the introduction of this machine into India would depend a great deal upon the price at which they could be supplied, and a great deal would depend also upon whether the chrysalides required to be killed for the purpose of reeling. A great many of the natives, particularly the followers of Vishnu, were averse to the taking of life in any shape whatever, and though they would spin or do anything with the cocoons gathered in the jungle from which the moths had emerged, they would not do anything with cocoons in which there was a live chrysalis.

Mr. Wardle, in reply, said some of the observations made would be found referred to in parts of the paper which he had not read. Dr. Birdwood did not intend to speak technically when he said that Tusser silk could be made as fine as China, because he did not think that could be done. With regard to the danger he feared of doing injustice to the native people, he could assure them that he shared his feeling, but if the increased cultivation and improvement of this undeveloped industry were worth anything, they must tend to give the natives of India more interest in their work, employ a much larger number, and result in the production of a vastly increased quantity of loudly called-for silk, as the discussion that evening had so satisfactorily shown. He also shared Dr. Birdwood's desire for originality in decoration, but the inventive faculty was an uncommon gift; and there could be no imitation in using for a portion of his lecture-illustrations the actual printing blocks the natives had themselves made and used; it was using the actual ornament, and not a simulation of it. With regard to the suggestion of first dyeing this silk one colour and then another, and thus making two vivid aniline dyes produce a better tone, they had a much quicker and more satisfactory mode of doing it, by simply putting two or more aniline dyes in the vat together. There was no doubt that any artistic colour could be matched with aniline dyes, the only difficulty was that mordants had not yet been discovered for that tinctorial matter, so as to allow the silk to be dyed in permanent colours. Hitherto they were all more or less fugitive. With regard to Mr. Cobb's interesting speech, he could allay his anxiety with regard to Tusser silk being dyed in weighted blacks in France, and then used to adulterate the best silks. The Tusser worms seemed to share his aversion to heavy blacks, and secreted their silken fibres in such a way that they resisted the weighting processes more than they resisted tinctorial matter. He had known it only increase a few ounces to the pound in an attempt to dye it a heavy black, when China silk had increased 32 ozs.; but with regard to its being mixed with better silk for various articles in colours, it was so used in France last year, and in England at present. With regard to fashion having brought in these silks, he thought it was just the other way, and that it was the fact of Tusser having been made amenable, by improved dyeing, to general requirements, which had led to manufacturers using it. He did not think the French were one whit in advance of what could be done in England in dyeing this silk, both by his own firm and several other principal dyers. The secret which Mr. Cobb could not discover from the French was this, and this only, for he was quite *au courant* with the development of French dyeing, but the air of mystery imparts a charm. It was the bleaching of the silk in the first place, for unless this were done, the pale colours could not be dyed; this effected, the rest was easy. He could have brought all shades of colour, even much paler than what he had shown. He was very glad to hear Mr. Cobb say Tusser cocoons were worth more than M. David estimated them at; so much the better for India. With regard to the late supply of Tusser waste, he was afraid distress in China had something to do with it; but, with regard to the waste in India, he did not think there was so much as 12 lbs. to one of silk. The Indians were very economical themselves; in one part of India they used the outer part of the cocoon for making armlets, and even brooches of; but still, if the people could be stimulated to grow more and export it, there would be plenty. With regard to the hybrid worm mentioned by Mr. Rogers, he doubted if he were correct, because the Yama-mai was a Japanese species, which was an oak feeder, whereas the Tusser worm fed on very dissimilar food. Still, it was very probable there had been a hybrid formed between the Tusser and some other kinds. The Tusser cocoon contains no tannin or woody matter. Mr. Wardle concluded by exhibiting a cocoon from South Africa of an immense size, being upwards of a foot long, the inside of which was filled with a number of smaller cocoons, which, he said, was the most curious thing he had ever seen. Still, there was something analogous to be found in some parts of England, minus the matted outer covering.

The Chairman proposed a vote of thanks to Mr. Wardle, not only for the work he had done, but for the modest way in which he spoke of his labours. He knew nothing about the subject himself, but he had taken a great interest in it from the few words he had with Mr. Wardle, about eighteen months ago, when he pointed out the advantages which would accrue from the encouragement of this industry. He would take the opportunity of laying this paper before Sir Louis Mallet and before the Colonial-office, and he hoped some solid advantages would result from the evening's discussion.

The vote of thanks was unanimously passed to Mr. Wardle, and the meeting adjourned.

The Indian silks, diagrams, entomological specimens, &c., shown by Mr. Wardle, to illustrate his paper, have been taken charge of by Messrs. Liberty and Co., of Regent-street, who have devoted a special room for their exhibition.

TWENTIETH ORDINARY MEETING.

Wednesday, May 7th, 1879; F. J. Bramwell, Esq., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Best, Frederick A., Church-hill, Walthamstow, E.
Corbett, Joseph, 24, Barton-arcade, Manchester.
Cutlers, The Master of the Worshipful Company of, Cutlers'-hall, Cloak-lane, E.C.
Flynt, William Garnett, Southport, Lancashire.
Freeman, William, 2, Lorne-villas, Brockley-road, Forest-hill, S.E.
Griffith, Edward F., 18, Abingdon-street, S.W.
Gentles, Thomas Lawrie, Wellington-house, Derby.
Kemp, Charles, Southerton, Ottery St. Mary, Devon.
Le Grand, Alfred, Magdala Works, Bunhill-row, E.C.
Lloyd, Thomas, Winchester, Hants.
Newton, George Robert, Heckington, Lincolnshire.
Ormsby, Arthur Sydney, 11, Kildare-gardens, Bayswater, W., and Scientific Club, Savile-row, W.
Phillips, John, 13, Gayton-crescent, Hampstead, N.W.
Yuill, W., 3, Fenchurch-avenue, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Allen, E., Herne-hill, S.E.
Atkinson, Richard James, 57, Tredegar-square, Bow, E.
Ball, Frederick, 18, Bell-street, Henley-on-Thames.
Beard, Neville, The Mount, Ashbourne, Derby.
Bostel, Daniel Thomas, 18 and 19, Duke-street, Brighton; and 8, Golden-lane, E.C.
Carter, Robert, 15 and 16, Minories, E.C.
Chapman, W., 5, Blenheim-road, St. John's-wood, N.W.
Croal, Thomas Allan, 16, London-street, Edinburgh.
Evans, Lewis Henry, 33, Walbrook, E.C.
Fenton, Myles, 22, Parkside, S.W.
Foottit, Robert, 96, Union-road, Rotherhithe, S.E.
Gardner, C. F., 2, Dean's-yard, Westminster, S.W.
Hale, Charles George, 12, Albert-mansions, Victoria-street, S.W.
Hubbard, Egerton, M.P., 24, Prince's-gate, S.W.
Hubbuck, Edward Martin, 24, Lime-street, E.C.
Jeffery, James, 2, Pen Olver-cottages, The Lizard, Cornwall.
Marsh, W. R., Rice Mills, Bromley, E.
Morris, William, 80, Old Broad-street, E.C.
Nicholson, W., 65, Goswell-road, E.C.
Ouvry, Frederic, 66, Lincoln's-inn-fields, W.C.
Pallett, Robert Henry Charles, Theydon-hall, Theydon Bois, Essex.
Park, Charles, 99, Long-acre, W.C.
Perkins, James, 13, Water-lane, E.C.
Pilbrow, James, F.S.A., Rock St. Michael, Hastings.
Risch, C. H. G., Belvedere-cottage, Lansdowne-road, Old Charlton, S.E.
Roberts, Richard, 15, New Broad-street, E.C.
Russell, Hon. Francis Albert Rollo, Pembroke-lodge, Richmond, Surrey.
Scott, Robert, Denzel, Altrincham.
Shone, Isaac, Mayor of Wrexham.
Snell, Henry Saxon, 22, Southampton-buildings, W.C.
Stahlschmidt, J. C. L., Southey-road, New Wimbledon, S.W.
Staples, H., Pewterers'-hall, Lime-street, E.C.
Sutcliff, Robert, Magdala Works, 100, Bunhill-row, E.C.
Talmadge, John Trinder, 53, Penn-road-villas, Holloway, N.
Tamblyn, Frederick, 2, Yarmouth-villas, Kingston-on-Thames.
Townend, James H., 16, Lime-street, E.C.
Viney, Ebenezer, Upper Norwood, S.E.
Wolstencroft, Thomas, 46, Ludgate-hill, E.C.
Watkin, Henry Samuel Spiller, 2, Nelson-villas, Stoke, Devonport.
Way, T. E., 9, Argyll-road, Castle-hill, Ealing, W.

The paper read was—

THE GOVERNMENT PATENT BILL.

By W. Lloyd Wise

Assoc. Inst. C.E., M. Inst. M.E., Assoc. Inst. N.A.

People are getting so tired of hearing about Patent-law reform, that some apology may appear to be due for introducing the subject on this occasion. The Act which mainly regulates the granting of patents in this country at the present time is known as the "Patent Law Amendment Act, 1852." It came into operation on the 1st October of that year. There are some subsequent Acts, namely, one of 21st February, 1853, substituting stamp duties for fees, and providing for the purchase, for public use, of certain indexes of specifications; an Act of the 20th of August, 1853, amending the Act of 1852 in certain respects, and explaining it; and an Act of 8th April, 1859, to amend the law with respect to inventions for improvements in instruments and munitions of war, but the Act of 1852 is the one on which our present system is based.

It is a remarkable fact that, although the law of 1852 has, on the whole, worked exceedingly well, there has been more or less agitation for reform or change during the greater part of its life. Thus, not to mention some, what I must be allowed to call ill-advised, attempts of certain persons holding very pronounced views, notably the late member for Leith, to bring about abolition of patents, there have been the Royal Commission, appointed in 1862, to inquire into the working of the law relating to Letters Patent for inventions; the Select Committee of the House of Commons, appointed in 1864, to inquire as to the most suitable arrangements to be made repecting the Patent-office Library and Museum; a Bill introduced in 1863 by Lord Alfred Churchill, the present chairman of your Council; the Select Committees on Letters Patent, appointed in 1871 and 1872; a Bill introduced some years ago by Mr. Hinde Palmer, Q.C.; Bills by the Lord Chancellor in 1875 and 1876; Bills by the Attorney-General in 1877 and 1879 (the latter of which, now before Parliament, is the one we are met to consider); and Bills by Mr. Anderson, one of which is also at the present time before Parliament. Besides these—and I am not sure they are all the Bills actually introduced—a Bill was drawn and printed a few years back by a committee of London patent agents.

In view of the magnitude of the interests involved, it is not surprising that people have been kept for years anxiously on the watch, numerous meetings have been held, petitions and memorials have been presented, and deputations have waited on those in office; nor is it to be wondered at that,

at length, people are growing weary of the whole subject. But this very weariness is a source of danger, since, in order to get a settlement, some measure may be allowed to pass containing features calculated to have an injurious influence upon the industrial and commercial prosperity of the country.

It is not the object of this paper to consider the expediency of protection for inventions, because that has long since been conceded; and were it otherwise, no better arguments could be adduced than are already to be found in the able paper read before this Society on the 2nd of December, 1874, by the gentleman who occupies the chair this evening. The aim of this paper is, by inducing discussion, to bring forth suggestions and opinions which may aid the Attorney-General and the Legislature in arriving at a satisfactory solution of the Patent-law amendment question, taking as a basis the Attorney-General's Bill already referred to.

There can be no doubt that he is as anxious as any of us can be, to put our Patent-laws in such a shape as shall conduce in the highest degree to the welfare of the country, and if there be differences of opinion as to some proposals made with this intent, it is to be recollected that the lawyer, the inventor, the manufacturer, each regards the subject from his own peculiar point of view, and, in the opinions he forms, is guided by his own special experience.

It would lead to a poor result were the settlement of the question left to any one class. It is by interchange of knowledge and opinions, as, for instance, at meetings like the present, that one acquires the practical information so essential in guiding to a satisfactory settlement of intricate questions, and in this light I invite you to regard the remarks I shall have the honour to submit for your consideration this evening.

The Attorney-General's Bill is unquestionably a great improvement upon those of 1875-6-7; as also, in many respects, upon the existing law. This Bill contains 59 clauses, the first four of which relate, respectively, to the short title, the commencement of the Act, the repeal of existing enactments, interpretation and construction. Clause 5 provides for the appointment, besides the *ex-officio* Commissioners of Patents as at present, of five additional unpaid commissioners. The fallacy of expecting satisfactory results from the gratuitous labours of unpaid Commissioners has been so forcibly and repeatedly shown in connection with previous Patent Bills, as to render it needless that your time should be taken up by any lengthy observations from me. It seems incredible that the proposal to appoint unpaid Commissioners could be persisted in, had not the Government good reason to expect that it will be able to secure the services of qualified men. On the other hand, it is difficult to conceive that really suitable men will be forthcoming. A principal reason for having additional Commissioners is that the *ex-officio* Commissioners are otherwise too fully occupied to give due attention to the business of the Patent-office. But if that holds good as respects the *ex-officio* Commissioners, is it not likely to apply equally to any really suitable men who might be selected to act as unpaid Commissioners? Scientific and legal gentlemen of the requisite standing certainly have not much spare time on their hands; whilst those having little or nothing to do, or those who would consider it so great an honour to hold the appointment of Commissioner as to require no other return, are not at all likely to be men who would inspire confidence on the part either of inventors or of the general public. If we are to have additional Commissioners, they ought, it would seem, to be, not unpractical busybodies, or men whose energies have been spent, and who have nothing left but their names, influence, and spare time; but sound, practical men, having legal and scientific attainments of a high order, coupled with business aptitude. Such men are surely not so numerous, or so short of work, as to desire appointments like the proposed unpaid Commisionerships.

According to clauses 6 and 7 of the Bill, an application for a patent is to be made by the applicant filing, at the office of the Commissioners, an application, a declaration, and a provisional specification describing the nature of the invention. Notice of the application, but not of the contents of the provisional specification, is to be published by the Commissioners, and the use and publication of the invention, after the application, and within a period of twelve months from its date, will not prejudice the grant of a patent for the invention. This protection is called provisional protection.

Now, it is not at all clear, on the face of the Bill, how these provisions are to be carried out. The Act of 1852 provides that the provisional specification shall be referred to the Attorney-General or Solicitor-General, who, if satisfied that it describes the nature of the invention, may allow provisional protection. But the Bill under notice contains no such provision. On the contrary, so far as clauses 6 and 7 go, it would seem as though the mere filing of an application, with declaration and specification, would at once establish the provisional protection. But, if this were so, how would those cases be met in which the alleged inventions might happen to be contrary to public morals, or the more likely cases of several distinct inventions being included in a single provisional specification, or of proper forms not being complied with, or the nature of the invention not being described? When one thus reflects, it seems scarcely probable that provisional protection is intended in every case to follow, as of course, on the filing of an application. This view is strengthened by subsequent provisions of the Bill, to one of which I must here briefly allude, although I shall have occasion to refer to it again. Clause 44 gives the Commissioners powers to make general rules, and do such things as they think expedient, for, among other things, prescribing and regulating the form and contents of applications, specification, and declarations. This seems to show that some active supervision is intended, and that applications not in due form may be rejected. It would be most inconvenient, however, should an applicant be liable to lose his priority of date, in consequence of the provisional specification not meeting with the approval of the Patent-office authorities. At present, except where discrepancies occur between the names and addresses, or the title, as given in the respective documents, the application is recorded as of the

date of leaving the application at the Patent-office. And other objections, whether in point of form or otherwise, to the provisional specification or other document, are communicated to the applicant or his agent, in writing, by the Attorney or Solicitor-General's Patent Clerk, so that the necessary corrections or amendments can be made, without altering the date of the provisional protection. It is to be hoped no material change will be made in this respect. There must be many cases of hardship, if an application is not to be treated as such in those cases where it may be open to objection; or, in other words, if objections, such as those now raised by the law officers, are required to be met and disposed of before the date recognised as that on which the provisional protection shall commence. Another question arising on this point, is the extent and character of the examination, if any, of the application, and its accompanying documents. In this respect it is to be hoped applicants for patents will be treated at least as leniently as they now are. Even under the present law and rules, there have been times when, at the instance of some meddlesome and crotchety law officer's clerks, applicants for patents have been subjected to vexatious delays and inconveniences, and under the Trade Marks Registration Acts and Rules there is much trouble and correspondence, and one cannot be certain that the authorities will hold the same views to-morrow as they do to-day.

The Bill is as elastic as respects the subsequent proceedings to obtain the patent, as in regard to the procedure on obtaining provisional protection. Clause 8 provides that not less than three months before the end of the period of provisional protection the applicant may file a complete specification, and should he fail to do so, shall be deemed to have abandoned the application, and the provisional protection shall thereupon cease. On the filing of the complete specification, the Commissioners are (under Clause 9) to make public the same and other documents relating to the application, including the provisional specification. The procedure contemplated is not explained, but I venture to assume the publication just referred to is intended to take place before the sealing of the patent, and this opinion is shared by others. There are several reasons for it. Publication of specifications is provided for, in the Bill, before mention of opposition, which first occurs in Clause 10. Under this, any person may, within the prescribed time, give notice of opposition to the grant; on such notice being given, the Commissioners are to refer the case to the law officer. He is, if required, to hear the applicant and any person so giving notice, and being in the law officer's opinion entitled to be heard in opposition to the grant; the assistance of an expert may be obtained and used; the law officer is to report to the Commissioners his opinion, whether a patent may be allowed or not, and they are to make public his report. Save in unopposed cases, it is only after the report of the law officer that the applicant will be allowed to give notice to proceed. This is under Clause 11. Now, although the present system of opposition on closed documents has its inconveniences, they are not, in my judgment, so grave as to justify the opposite extreme course of throwing open to the world the whole of the inventor's secret, the result, may be, of much thought, time, and expenditure, before giving him any grant. If, in any sense, a patent represents a bargain between the inventor and the public, the former giving a full explanation of some new invention, and of the manner of carrying it into practical effect, as devised by him, in exchange for an exclusive right of enjoyment for a limited term, it is not unreasonable, as a means of ensuring that he shall fulfil his part of the contract, to require him to file his full description before he receives his grant. But to make the whole thing public and then to refuse the grant is quite another thing, and would be not only manifestly unjust, but also inexpedient, for it would tend to induce suppression of material information in specifications. Intending patentees would very naturally reason that to disclose all the secrets of, for instance, a new process of manufacture, before being assured of some exclusive enjoyment, would be suicidal. It would be probably more remunerative to take the risk of trying to work it in secret. Let us assume the very probable case of a person having invented a thing he believes to be essentially new, claiming in his complete specification the main idea, but giving also (as in duty bound) full explanations of his mode of carrying out such idea. Suppose his application for a patent to be opposed (as it might be) on the ground that the main idea claimed in his specification had been anticipated by some user or publication, and that what remained was not enough to support a patent. Thus, he might be refused a patent, and yet his specification might, and, probably often would, contain much valuable matter which, but for the publicity given to it, might for a considerable time be exclusively enjoyed by the inventor, or embodied with other matter in a new application for Letters Patent. Not only so, but an inventor of limited means—and, believe me, there are many such—might, through no other fault than his poverty, or comparative poverty, be deprived of his invention. I know some will feel amused, and others disgusted, at the mere mention of the poor inventor—but I would earnestly ask them to bear with my observations on this point. Opposition, even before the law officer—to say nothing of one before the Lord Chancellor—is a very serious thing indeed for an applicant, when his means are small, and his opponents' purse is long. To meet an opposition with reasonable hope of success involves the securing of professional aid, and, sometimes, the costs attendant on meeting an opposition, amount alone to more than the total cost of obtaining an unopposed patent. Hence, even under the existing law and practice, with closed documents, it has happened (I do not say frequently) that an applicant, on meeting with opposition he had not the means to contend against, has abandoned his application for a patent. This becomes an important consideration when it is remembered that, as was well pointed out by an experienced witness before the Select Committee of 1872, if an application were made public, so that all the trade might examine it, and see what it was they would, in the future, have to cope with, their interest would be great, if the thing were a valuable one, to defeat the inventor in the first instance, to prevent his getting a position which would be placing him above them in the estimation of the

public. The same witness said that any opposition arising on open documents would be substantially a law-suit, whereas an opposition on closed documents was a simple comparison of documentary evidence.

Some very plausible reasons have been adduced in favour of giving publicity to the full description, so as to facilitate opposition before the sealing of the patent. It has been urged that manufacturers should not be subject to the risk of having patented over their heads something already used by them, and in respect of which they would then become liable to claims for royalty, without being first fully apprised of the nature of the intended grant, and afforded the opportunity of opposing it. This means, under the new Bill, not only proceedings before the law officer, but also an appeal to the Lord Chancellor; and as Clause 23 (which repeals the proceeding by *scire facias*) provides for revocation of a patent on petition to the Lord Chancellor, the publication of complete specifications before the sealing becomes clearly an unnecessary, not to say an undesirable, addition to the difficulties of inventors. It has also been argued that were all complete specifications made public before the sealing, patent property would acquire a higher standard of value, as every patented invention would, so to speak, have successfully undergone a sort of test. The answer to this is simple. The more worthless the invention, the less likely would it be to meet with any opposition—the more valuable an invention, or, in other words, the more likely it might be to materially affect the interests of manufacturers, the more certain would it be to meet with opposition. Thus, an application for a patent, in respect of an invention likely to greatly reduce the cost to the public of a given article of manufacture would, in all probability, meet with strong opposition on the part of manufacturers engaged in manufacturing like articles by older and more costly processes. If the inventor should, unfortunately, not be able, in a pecuniary sense, to withstand the opposition, he might be compelled to abandon the matter, and, in this way, the public might lose the benefit that would otherwise arise from the introduction of the invention. On the other hand, a patent for a worthless or an old invention, having successfully passed the so-called test, would go before the world with a false colour. A little reflection will show that this is not a desirable feature; it would create misplaced confidence, for the more the public are led to suppose that the existence of a patent is evidence of its validity, the less precaution will uninitiated persons take before embarking their capital. It is a common error to suppose a patent granted in the United States or Germany must be valid. As a fact, such patents are often bad, and may be upset, notwithstanding all the display of precaution attending the granting of patents in those countries.

There is much more that might be said on this point, did time permit, but the balance of advantages does not appear to be in favour of the prior publication of complete specifications. If, for any reason, it be ultimately decided not to give a patent to an applicant, he should, at least, be left in as good a position as he would have been in had he never sought a patent. This cannot be the case if the full description be made public. If a patent is refused to the applicant, he ought to be entitled to the benefit of the private use of any novel features described in his complete specification.

Clauses 12, 13, 14, and 15, relate to sealing. If there be no opposition, or the law officer reports in favour of the application, the Commissioners are, on the notice to proceed, to submit to the Lord Chancellor a form of patent, with a warrant for the sealing thereof. If the law officer reports against the application, the applicant may petition the Lord Chancellor for the grant and sealing of a patent. This is a valuable concession. At present, the applicant has no appeal against the law officer's decision. Consequently, where that officer forms an erroneous opinion, and refuses a patent, irreparable injury is done to the inventor. The Bill also provides, that any person may petition the Lord Chancellor against the sealing of a patent. There would be no serious objection to this, if restricted to cases where there had been no opposition by the same objector before the law officer; and where it could be shown that the information on which the opposition was based had come to his knowledge after the time prescribed for opposing before the law officer. But if patents are to be revocable on petition to the Lord Chancellor, surely there can be no need of an appeal to him against the granting of a patent where the law officer shall have reported in favour of the application after duly considering the same grounds of objection. Open documents, opposition before the law officer, and appeal from his decision to the Lord Chancellor, make up a rather alarming array of obstacles in the inventor's path. I have yet to learn there is any sufficient reason for thus hampering the applicant for a patent, which is to be liable to revocation in the manner referred to. A serious defect in the Bill is that it would allow of racing for the seal. To make my meaning clear, let us suppose that two persons, whom I will call A and B, independently invented the same thing, and that A applied for provisional protection a month earlier than B. Should B file his complete specification earlier than A, and take the other prescribed steps, he might be the first to get a patent. On A subsequently taking steps to obtain his seal, B might successfully oppose the application, by pointing out to the law officer or the Lord Chancellor, that a patent had been already granted to him, B, for the invention sought to be patented by A. According to present practice, A's application for a patent would be refused, thus rendering the provisional protection on which he had been relying practically valueless. The new Bill, instead of curing this acknowledged evil, expressly provides that, where the warrant or the Lord Chancellor so directs, a patent may be dated the day of the sealing, or any day between the day of the application and the day of the sealing. Every patent ought to be dated the day of the application, and sealed as of that date, and it should not be an objection to the sealing of a patent, that a patent for the same invention, on a subsequent application, has been already sealed.

Clause 16 contains some valuable concessions, including extension of term to 21 years, substitution, at the times of paying periodical stamp duties, of request in writing for certificate of renewal in lieu of production of Letters Patent, first for

stamping, and subsequently for registration at the Patent-office; also, enlargement of time (should the Lord Chancellor think fit) where, by accident, mistake, or inadvertence, the patentee fails to take out a certificate of renewal within the prescribed time. The extension of term is a great boon. At present the Privy Council may prolong a patent for 14 years, thus giving a total term of 28 years; but applications to the Privy Council are so costly as to render this provision of the law unavailing in most of the very cases it was intended to meet, namely, those in which the patentee has not been sufficiently remunerated. A patentee who has devoted many years of his life, and perhaps nearly all, if not the whole, of his means to the working out and introduction of or attempt to introduce his invention, is scarcely in a position to afford an expenditure of hundreds of pounds in applying for a prolongation of his patent, which may be refused, or, if granted, may be abitrarily given for so short a term as to be practically valueless. The Bill limits to three months the enlargement of time the Lord Chancellor may grant for taking out a certificate of renewal. Six months would appear not too much; and, as experience has shown that powers to be exercised in the discretion of Lord Chancellors are differently exercised by different Chancellors, it would be more satisfactory were enlargement of time granted, as is the case, for example, in the case of the payment of annuities in Belgium (where there is six months' grace), Italy, and Germany, but subject to a substantial fine, which would be cheerfully paid where accident or oversight arose, such as would otherwise involve the loss of a patent, with no other remedy than the present one—an appeal to Parliament for a special Act.

Clause 17 will be received with satisfaction, inasmuch as, besides allowing of amendment by way of disclaimer, explanation, or otherwise, it will enable an applicant or patentee to add to the specification any supplementary invention such as, if known at the date of the application for the original patent, might have been properly comprised in the specification on that application. The applicant or patentee will have to declare himself to be the first and true inventor of the supplementary invention, or to declare and show himself to have the consent of the true and first inventor thereof to the amendment. This is a valuable feature in the Bill. It has long been recognised in the laws of foreign countries that, in the course of developing a patented invention, improvements may from time to time be made, such as—whilst scarcely of sufficient importance to be separately and independently patented—ought, nevertheless, to be known, so as to enable the public to have the full benefit of the main invention on the termination of the original patent. Such minor improvements are frequently of much practical value, and patentees have not naturally a propensity to giving them to the world gratuitously. Hence, a provision which enables a patentee to readily make his patent specification accord with his practice, will be advantageous, not only to him, by reason of the additional security it will afford, but also to the public, who will, on the termination of the patent, acquire a knowledge of the invention in a perfected form. As regards amendments, otherwise than by way of supplement, I think the clause in the Bill should be altered. As it now stands, no such amendment would be allowed, if it would make the specification, as amended, claim an invention substantially larger than, or substantially different from, the invention "claimed by" the specification as it previously stood. For the words "claimed by," it would appear reasonable to substitute the words "contained in," so as to meet cases of inadvertent omission of claims in respect of novel features contained in specifications. In the United States, such omissions may be corrected by what is called a re-issue.

Clause 18 says a patent shall have to all intents the like effect as against her Majesty the Queen, her heirs and successors, as it has against a subject. The officers or authorities administering any department of the service of the Crown may, by themselves, their agents, contractors, or others, use the invention for the service of the Crown, on terms to be agreed on, with the approval of the Treasury, between those officers and the patentee, or, in default of agreement, settled by the Treasury with the advice and assistance of the Commissioners. I have found the heads of important departments are not all favourable to this innovation. By some it is regarded as fraught with danger, and considered likely to prove most embarassing to the public service. It has also been suggested to me that, if the State is to pay patentees for their inventions, it is only fair Government servants should likewise be remunerated for their inventions when adopted by Government. In this I quite concur. In 1877, the Chief of Ordnance of the United States, in an official report, expressed his opinion that the Government of that country had no legal or equitable right to take the property of an inventor, secured to him by the law and by the grant of Letters Patent, and apply the same to its own use, gain, or profit, without a just and fair compensation therefor, any more than it would have to seize the personal and real property of a citizen, and drive him and his family from their home, and, without compensation, deprive them of their daily earnings, or of their horse, cattle and house. He said, with reference to the use by Government of that kind of property protected and secured by Letters' Patent, it should be fairly adjudicated and determined, as between the Government and the patentee, in the least expensive and most expeditious manner possible. On these points, in principle, there will probably be no dispute. But the mode of adjudication is a difficult problem, and one the Attorney-General has not yet succeeded in solving to the satisfaction of all parties. Nor has he been more successful in Clause 19, which would make a patent liable to revocation at any time after the end of three years from its date, should the patentee fail to use or put in practice the invention, by himself or his licensees, to a reasonable extent, or to make reasonable efforts to secure the use or practice of it, proof to the contrary whereof would lie on him; or if, in order to ensure a proper supply to the public of articles produced under the patent, or proper means for the use of the invention by the public, licenses were necessary, and the patentee failed to grant licenses to proper persons requesting the same, on terms which the Lord Chancellor, having

regard to all the circumstances of the case, might deem reasonable. Any greater state of uncertainty than would attach to patent property under such indefinite and elastic provisions, it would be difficult to conceive. Under the existing German law it is, in practice, not possible to ascertain what a patentee is really bound to do to ensure the validity of his patent, as respects the working or use of his invention; and now it is proposed we should establish an equally vicious system here. I connot bring myself to believe any one of large experience in the working of foreign laws, will really approve of the Attorney-General's 19th clause. Formerly there was a provision of an analogous kind in the United States law, but having proved, as it was bound to do, a dead letter in practice, it was altogether omitted from the new law.

Clauses 20, 21, and 22, relate to assignments and licences, and do not appear to call for special remark.

Revocation of a patent, on petition to the Lord Chancellor, is provided, as already mentioned, in Clause 23, which states that any ground on which a patent might at the commencement of the Act be repealed on a proceeding by *scire facias* shall, in addition to any ground specified in the Bill, be a ground of revocation.

Clause 24, relating to what are there called "imported inventions," contains a strange mixture of good and bad features. An invention is to be deemed an "imported invention" if it was first invented and used abroad, or if, at the time of application for a patent here, there is in respect of the invention a foreign or colonial grant in force, or if the person making the application is resident abroad, or if he is an alien. Where, at the time of application here in respect of an imported invention there is not any foreign or colonial grant in respect thereof in force, a patent is not to be granted for it to any person but the actual inventor, or his legal personal representative (by himself, or by his attorney or agent). I presume that should there be independent inventors, this clause will be interpreted on the principle of "first come, first served." Where, at the time of application here in respect of an imported invention, there is any foreign or colonial grant in respect thereof in force, a patent is not to be granted for it to any person but the foreign or colonial grantee, or his legal representative (by himself, or by his attorney or agent) and is not to be granted to him unless he makes the application within six months from the date of the foreign or colonial grant, or of the earliest thereof, if there are more than one. From this it would appear—not to mention other weak points—that when an invention has been once patented abroad, no one who may independently make a similar invention will be in a position to obtain a valid patent here, even should the invention be quite unknown here at the date of his application. If this view be correct, the provision in question would seem to be a very decided step in the wrong direction. Again, why should this country say, as the clause under notice virtually does, "You shall not bring your invention here at all, if you don't bring it within six months." Surely, if an invention be new here, we had better have it ultimately, even if it be six years coming. If we refuse to give any return unless we get it within six months, the probabilities are that those inventions not received within that time, will rarely, if ever, be commercially introduced here at all. It is satisfactory to find that the validity of a patent granted here in respect of an invention already patented elsewhere is not to be affected by the publication in the United Kingdom of the imported invention by the circulation or re-publication within six months from the date of the foreign or colonial grant, of copies of the same, or of any specification, or other document officially connected with that grant. This is a very necessary provision, in these days of rapid communication, and interchange of official and other publications. I am, however, a little doubtful whether the words of the Bill are quite large enough to include all kinds of publication it would be just and expedient to provide against.

I now come to a provision that cannot be too strongly condemned, although it is copied from our existing Patent-law, and has been largely adopted in the laws of other countries—I mean the provision that a patent in respect of an imported invention, previously patented elsewhere, shall cease on the cesser of the prior foreign or colonial grant, or of the first thereof to cease, if there are more than one. I have never heard a good reason assigned for any such provision. It seems absurd to say that if a Swede invents a thing, he shall have a patent here for fourteen years if he obtains it to-day, and delays obtaining his Swedish patent till to-morrow, but that if he obtains his Swedish patent to-day, and his English one to-morrow, his English shall die with his Swedish patent. If the English and Swedish patents both bear the same date, the lucky inventor is probably safe. I will not take up your time with numerous other remarks I might make on this point, but would say that such provisions go far to render patent property precarious, and to place difficulties in the way of the commercial working of patented inventions.

It seems undesirable to refuse a patent in respect of an invention, a foreign or colonial patent for which shall have ceased prior to the application here. If the invention be already publicly known here, of course the case is different, but otherwise it is difficult to conceive why we should be unwilling to give some return to the introducer of an invention new to us, especially seeing that in the very nature of things, that return can only be proportionate to the proved value of the invention to the community.

Clause 25 relates to the use of inventions on foreign vessels in British waters; Clauses 26 to 29, inclusive, to fraud and offences. It would be an improvement to provide that a patent granted to the true and first inventor should not be invalidated by a patent obtained in fraud of him. It would also appear desirable to make some provision against the not uncommon practice of deceiving the public by using the word "patent" on and in connection with articles which are not and have not been patented. Clauses 30 to 39, inclusive, have reference to procedure.

The law officer is empowered by Clause 30 to administer and take oaths and declarations. No doubt this would often be of material assistance in cases of opposition, and would tend to reduce the

number of appeals to the Lord Chancellor. It may, however, be well to consider whether a practice might probably arise, such as would demand the expenditure of more time than the law officers could afford. Clause 32 empowers the Lord Chancellor to enlarge the period of provisional protection to fifteen months at most from its original date—a term which possibly might in some special cases prove barely sufficient; also to enlarge the period within which the request for sealing is to be made and the patent sealed.

Probably this clause would allow of additional time for filing the complete specification, when through accident, or inadvertence, the proper time had been passed. But on this point the Bill might, perhaps with advantage, be made a little more clear.

According to Clause 33, no appeal is to lie from a determination or order of the Lord Chancellor in respect of or on a petition. Seeing how different have been the views of various Lord Chancellors in respect to patents, it would seem only just to allow the patentee an appeal where the Lord Chancellor decides against him on a petition for revocation of his patent. Under Clause 36, on a petition the Lord Chancellor, and in an action for infringement the judge, may obtain the assistance of an expert. It will probably be difficult to find an expert who is not himself a patentee, but it is to be presumed no one would serve as expert in a case who had any sort of interest that might even remotely influence his judgment.

Clauses 40 to 46 inclusive, relate to proceedings of the Commissioners. Under Clause 43, the Commissioners may from time to time, subject to the approval of the Treasury, appoint as many officers and clerks, with such designations and duties as the Commissioners think fit. This would apparently enable the Commissioners to appoint examiners.

The next clause empowers the Commissioners to make from time to time such general rules and do such things as they think expedient, subject to the provisions of the Act and of general orders thereunder, for a variety of purposes, including the prescribing and regulating the form and contents of applications, specifications, drawings, and reports; the publishing, opening to inspection, printing and selling of copies thereof, and for prescribing the deposit of models in such cases as the Commissioners think fit.

In short, so extensive are the powers given to the Commissioners, and so indefinite is the Bill as to the mode in which these powers may be exercised, that one cannot help some feeling of anxiety lest, should the Bill become law, we might awake some fine morning to find a practice established, under rules of a character as objectionable as might have obtained under the examination clauses of the much opposed Bills of 1875-6 and 7. It would be satisfactory to know whether a system of preliminary examination is contemplated, and if so, what is to be its precise character. If there is to be preliminary examination, it should be strictly confined to the questions whether the application is in form, the invention contrary to public morals, or wanting in novelty, regard being had only to prior publications printed during the past twenty-one years, or to actual user during that period, and whether the specifications are clear. It is of the utmost importance that the terms should be strictly complied with of the resolution adopted at the Conference held in this hall on the 6th of March, 1877, and which I had the honour of submitting to the recent Congress at Paris, where a resolution similar in effect was passed, namely, that no adverse report of an examiner, even with a right of appeal, ought to preclude an applicant from obtaining a patent, at his own cost and risk; and, further, that reports containing opinions of Patent-office authorities ought not to be made public, but that opportunity should be given to the applicant of amending his specification, by inserting reference to matters discovered by the authorities, with a definite statement of what he, nevertheless, claims.

The proposal to empower the Commissioners to prescribe the deposit of models, is, in my judgment, decidedly objectionable, and will meet with strong opposition from those who have experienced the inconvenience and expense the like requirement involves in the case of an application for a United States' patent. I have frequently known the model to cost considerably more than the total cost of the patent, considered irrespectively of the model.

Clause 47 relates to the stamp duties, which, according to the schedule, are to be £2 10s. on application for a patent, £10 on the patent, £50 before the end of the third year, £100 before the end of the seventh year, and a further £100 before the end of the 12th year. It would be satisfactory if the Treasury could be induced to approve of some material reduction in these stamp duties. It seems radically wrong to place such a heavy tax upon invention.

Clauses 48 to 51 refer especially to Scotland, Clause 52 to Ireland, Clauses 53 to 56 contain transitory provisions, and Clauses 57 to 59, inclusive, are saving clauses. I have trespassed so much upon your valuable time and patience that I will not now trouble you with any remarks on these various clauses, particularly as they do not appear to call for any very special observation, excepting, perhaps, a suggestion that it may be well to consider the expediency of extending to existing patents the provision of the Bill as to extension of term to 21 years.

In conclusion, perhaps I may be allowed to say it would be well if effect could be given to a suggestion of the late Mr. Hindmarch, Q.C., in his report as one of the Royal Commissioners appointed in 1862 to inquire into the working of the Patent-laws. He recommended that the names of the then existing patent agents should be registered in the office of the Commissioners of Patents, and that no person should thereafter be permitted to practise as a patent agent until examined by some competent authority, in order to ascertain his competency; and that all persons so registered as patent agents should annually obtain certificates of their right to practise, and should be made liable to be punished for misconduct by the Lord Chancellor or the Master of the Rolls.

I venture to mention this matter as one to which my attention has been frequently directed, and which I have been urged to bring forward.

DISCUSSION.

The Secretary read the following communication from the Secretary of the Committee of Glasgow Inventors:—

Sir,—Mr. James R. Napier, F.R.S., a leading member of the Committee of Inventors, in Glasgow, who has taken an active part in the matter of Patent-law reform during the past five years, has just handed me your notice intimating that Mr. Lloyd Wise is to read a paper to-morrow, the 7th inst., on the Government Patent Bill, at present before Parliament; and he (Mr. Napier) has requested me, as Secretary of the above-named Committee, to communicate to you the views of our Committee and of the leading inventors here, believing that you and other members of your Society may feel interested in what has been done in Glasgow on this important question.

I have, therefore, the pleasure of enclosing you a copy of the Parliamentary paper, containing a print of the petition from the public meeting of Glasgow Inventors, presided over by Sir William Thomson, which will show you the position taken up by them upon the principal clauses of the Government Patent Bill. As supplementary to, and explanatory of, the petition, I would submit to you a short analysis of the arguments put forward at the meeting referred to.

In the first place, it was unanimously agreed that Clause 9 of the Bill, providing for making public the complete specification and drawings, and allowing opposition thereon, before the issue of the patent, would be a very dangerous and impolitic departure from the hitherto well tested and approved system of granting the patent before the documents are made public; under the provision that the patentee subsequently files, on his own responsibility, a complete specification for the use of the public after the expiration of the patent rights. The said clause was accordingly condemned, as it would afford unlimited facilities for the wealthier manufacturers and patentees to obstruct the issue of patents to the poorer class of inventors in the same department of trade, which would ultimately discourage applications for patents by the latter class, the natural consequence of which would be, a decline of improvement in our industrial arts and manufactures, to the detriment of our national prosperity, as compared with other countries, having more liberal Patent-laws, which are found to foster and develop inventions.

As to Clause 19 of the Bill, which provides for the revocation of patents at the end of three (or practically two) years, on grounds of non-licensing or non-using, you will observe that, while not directly opposing the clause, it was agreed that revocation on such grounds should not take effect earlier than the fifth year. A numerous minority, however, were quite opposed to the clause, on account of its unfairness in some cases, and its impracticability in others; as many inventions could not practically be worked in so short a period, and until an invention is successfully introduced, licenses would not be asked for; hence, as the whole burden of responsibility of bringing the invention to a successful issue rests with the patentee, it seems unjust that he should be compelled to share the ultimate benefit with rivals who have stood quietly by to watch the result.

With regard to Clause 53 of the Bill, it was unanimously agreed to be a manifest injustice to abolish the existing privilege of getting present patents prolonged by the Privy Council beyond the fourteen years, without providing some substitute for it in the Bill; as there can be no sound reason why an invention made in January, 1880, should be esteemed of more value, or entitled to seven years longer monopoly than one made in December, 1879. And, apart from this, we have to consider the propriety of maintaining invested interests in patent property intact, as so clearly recognised under the present law.

The power to call for models was also strongly objected to, as it would entail much expense upon the applicant in all cases where complicated machinery is concerned, and the officials of the Patent-office attending to this department should be well able to understand an invention from descriptions and drawings.

Regarding the stamp duties proposed in Schedule 2, it was considered that the reduction of the initial payments on obtaining the patent was a great improvement, but it was agreed that the periodic taxes should be postponed in dates and reduced in amounts more in the direction of Mr. Anderson's Bill—namely, £25 at the 7th year, and £50 at the 14th year. The tax of £50 at the third year was unanimously condemned, as it is found to be oppressive, and, falling due so early, it renders void a large number of useful patents, which, by ceasing to be the special property of their owners, are no longer further developed for the benefit of either the patentee or the public.

The power to obtain supplementary patents was considered likely to prove a great boon to many inventors who are frequently making improvements upon their original inventions, but who may not be prepared to incur the responsibility of paying the periodic taxes.

Such were the opinions of the inventors of Glasgow in public meeting assembled, as drafted by their Committee, and as embodied generally in their petition to Parliament; and it may interest you further to know that the Philosophical Society of Glasgow prepared and sent in a petition in almost identical terms. A public meeting of inventors in Edinburgh also prepared and forwarded a similar petition, with the principal exception that, by a majority, they objected altogether to compulsory licensing. A number of the trades societies, on the other hand, have petitioned against the Government Bill, and in favour of Mr. Anderson's Bill, the latter being altogether more adapted to their circumstances, and more in terms of their petitions to Parliament in previous sessions.

While writing, I have been favoured with a perusal of the printed report and resolutions of the Committee of the British Association; and it is gratifying to find that these resolutions are mainly in harmony with those of the Glasgow Philosophical Society and the meetings of Inventors, already referred to, except as to the duration of patents, and the periodic taxes. If patents are to be granted for 21 years, in terms of the Bill—and this has been the term prayed for in nearly all the petitions to the present and four past sessions of Parliament—then the most most natural term for levying the taxes would be at successive periods of seven years. It appears suicidal, however, for the Committee of the British Association to suggest 17 years as the life of the patent when the Government offers 21 years. Such a concession, coming from the reputed friends of inventors, is very apt to give the opposite party an argument for adhering to the old system of 14 years; and it is much to be regretted that such a concession should have been made by so influential a representative body as the Committee of the British Association. That committee, however, have taken a very decided stand against Clause 9 of the Bill, and have shown excellent reasons why the specification should not be made public (to invite opposition) before the issue of the patent; but it is singular that in the report no notice is taken of the serious omission in the Bill for extending existing patents to periods corresponding with the new patents. By reading section 2 of Clause 53, with section 4 of same clause, which commences with the words, "In all other respects," it appears that section 2 fixes the terms of existing patents, but that in other respects the forms and regulations in force will remain the same as at present. The Bill clearly abolishes the power of prolonging patents by the Privy Council, and if, in future, they cannot be otherwise prolonged, it will not only be a great grievance to the proprietors of existing patents, but it would also delay the introduction or development of any improvements during the period which may elapse between the passing of the Act, and the date on which it comes into operation; as inventors would naturally prefer waiting six months or

so, with the hope of securing the longer term of monopoly under the new Act.

Altogether, our Committee highly approve of Mr. Anderson's motion at present on the notice paper of the House of Commons, which is to the following effect:—"That, in the opinion of this House, no measure of change in the Patent-laws will be satisfactory to the country, if it continues to treat inventors as public enemies, to be impeded and heavily taxed, instead of legislating so as to stimulate in the inventive genius of the nation to bring improved machinery and labour-serving appliances to the aid of our depressed manufacturing industries." Unless, therefore, the Government Bill is altered in the direction hereinbefore indicated, it is evident no attempt is intended to stimulate the inventive genius of the nation, but rather the reverse; and the majority of inventors in Glasgow would prefer to have no legislation at all at the present time, rather than have the Government Bill as it stands.

If agreeable to you, and not informal, it would greatly please the Committee here to have this letter read to your meeting to-morrow, as it might lead to some unity of action being taken by the various societies at present working towards some settlement of this important question, which has been so ineffectually agitated for about seventeen years.

John Brown,
Secretary of Committee of
Glasgow Inventors.

96, Buckingham-street, Glasgow,
6th May, 1879.

The Chairman said he was glad to find the way paved for the few preliminary remarks he had to make, by the last paragraph in the letter just read by the Secretary, wherein a quotation was made from Mr. Anderson's resolution before the House of Commons. The writer of the paper had evidently supposed that on this occasion, at all events, there would be no question as to whether or not there should be any Patent-law, and that the matter to be now discussed was merely what should be the improvement in the existing law. Many persons, however, gave a grudging assent to the necessity for a Patent-law, and looked upon those protected by it as, in some sense, adversaries of the public at large, but he would wish to disabuse such persons, if there were any present, of that idea. Dr. Siemens had put the matter most pithily in saying that he was convinced it would be to the benefit of the whole community, if an invention should be found lying in the gutter, that an owner should be assigned to it, rather than that it should be left to be the property of the public at large. Figurative as that expression was, he believed it was no more than the truth. Mr. Wise had well remarked that, with open documents, so far from the absence of opposition proving that a patent which passed was a good patent, it would have the effect that only valuable, and not useless, patents would be opposed. So far from its being the desire of persons engaged in manufacture to adopt new inventions, the truth was that such persons dreaded nothing more than the introduction of new machinery; and naturally enough. When they had their machinery set up to work a certain process, and their workmen trained to use it, they were not too ready to adopt any new idea which came before them. It simply placed them in the dilemma of either leaving it alone, which would be the easiest thing to do, or adopting it at an enormous expense. Of course, they would be inclined to leave it, but they knew that, if other manufacturers took the invention up, they would have an advantage over those who declined to adopt it. In short, the tendency of manufacturers was to leave inventions alone, unless they were very enterprising men, who desired to push themselves forward. An inventor was generally a man not engaged in a particular trade, and whose ideas were not trammelled by any preconceived notions. Such men might be very unfavourably placed for carrying out their inventions—without capital, business knowledge, or connections—and therefore incapable by themselves of developing their inventions; but protected by a patent, they could go to a capitalist and induce him to bring it forward by offering him special privileges for so doing. Thereupon there was a temptation to adopt it, and it was brought forward. The object should, therefore, be to see whether or not certain provisions in the present Bill, which they would admit was a great improvement on the existing law, and on the preceding abortive Bills, were calculated to promote this result. In discussing it, they ought to consider whether some of the clauses had not been framed on the old-fashioned notion that the inventor, protected by the patent, was in some sense the adversary of the public. If that feeling had not prevailed, he did not think some of the clauses would have been introduced, particularly those relating to imported inventions as they were called. There seemed to be a desire in the minds of the framers of the Bill to take advantage of the invention without protecting the inventor, and the prevailing idea seemed to be that if the public could get something without giving an equivalent in the shape of protection to the inventor, it would be so much gain. He had the honour some years ago of reading a paper on the expediency of Patent-laws before the Society, when he dealt with the question, was it for the benefit of the community as a whole that they should exist, and he would not now go beyond that point. He thought there should be some person sufficiently interested in every novelty, to endeavour to induce those to take advantage of it whose interest it was not to do so. With regard to imported inventions, he might give one illustration. An American gentleman invented a particular form of hull for steam-ships, and on the experiments connected with that invention he spent between £200,000 and £250,000, partly in America, but very largely in England. He applied to the Privy Council for a prolongation of his patent, being willing to go on with his expenditure, but having taken out a foreign patent and suffered it to lapse, that prolongation was refused him, although he had expended so much on the invention, and had up to that time nothing to show for it except two or three experimental steam-ships, The result was that he was no longer encouraged to continue his expenditure on what certainly appeared to be a great improvement. The ground suggested for the refusal was this: that if a man took out a patent in France, thereby informing the French of the nature of his invention, and if he had suffered his patent there to lapse, the French shipbuilder could adopt the invention without paying a royalty, and the shipbuilders in England would be placed at a disadvantage. The answer to that was—How would they have been in a better position if he had never taken out his patent in France at all? He supposed that as there was no connection with France, no postal service, no telegraph, no newspapers, no communication of any kind, the French would have remained ignorant of the whole matter unless the inventor had taken out his patent there! He trusted that before this Bill became law, those who had charge of it would wholly disregard the considerations to which he had alluded, as he believed they simply followed ideas formed at a time when people in one country knew but little of what was going on in another; and he hoped they would not allow the life of a patent in one country to depend on the question whether or not it had lapsed in another. He hoped there would be a good discussion, and that any objections there might be to any of these clauses would be brought forward, so that they might go before the law officers of the Crown. He was quite sure the Attorney-General had but one object, viz., that the Bill should be satisfactory to those whose interests

it was intended to promote, which meant the whole public inventors and non-inventors alike.

Mr. Anderson, M.P., had always held the view that there was really no difference between the interests of the public and of inventors in the matter, and that to stimulate the inventive genius of the country would be most beneficial to all. In fact, after considerable experience, he had come to the conclusion that two things were needed to put our manufacturing industries in a more satisfactory position, and they were—technical education, as given on the Continent, and the conferring of liberal patent rights, so that inventive genius might be induced to come forward and assist the manufacturers here as in other countries. They had in America an instance of the results of liberal patent laws. Most modern inventions came thence; not because people's brains there were more inventive, but on account of facilities and encouragement given by their patent regulations. There, a patent could be taken out for about 35 dols., but in this country it would cost £175, and a much larger expenditure was required if a prolongation were applied for after the expiration of 14 years. With regard to publication, no worse provision could be devised than to insist that no inventor should make known his secret to the public before he could know whether he was to obtain a patent or not, and the natural consequence of such a clause would simply be to burke patents, because inventors would rather try to get whatever profit they could by working their inventions secretly than have their applications clogged with such a condition. He entirely approved of the clause for extension to 21 years, but it should not be limited to new patents to the exclusion of those now in existence. As to the use of patents by the Government, it would be rather hard on poor patentees that the Treasury should be made the sole arbiter of the payment they should receive for the use of their inventions, the object of the Treasury officials being, of course, to get whatever they could for the public and for the Government at as cheap a rate as possible. The provision for the compulsory use of patents seemed unnecessary, because it was the interest of patentees to get the public to adopt the inventions and not to let them lie idle. The only instance he could recall, in which such a clause could have been called for, was with regard to the Plimpton skates the patentee of which thought his interests were best secured by granting licenses to joint stock companies only. The provision for the deposits was a distinct grievance on account of cost; and that for payment to be made at the end of the third year, was as bad as anything could be. No payment should be exacted until the seventh year, otherwise a poor man would be forced to pay before he had got anything out of his patent, and before he might have been able to make the necessary improvements to render his invention workable and valuable. The payment, too, at the end of seven years, was too large, and should be only enforceable in the fourteenth year, when the inventor would know thoroughly what his patent was, and would probably have made money by it, so that there would be no harm then in making him pay handsomely for a prolongation. In his own Bill he had made the first payment £10, but he would prefer to strike out the payment in the third year altogether, and to make that in the seventh year, as in his own Bill, only half what the Government proposed. He regretted that the Government appeared to regard inventors in some degree as the enemies of the public, and the Attorney-General last year refused to help him with his own Bill "because it was a patentee's measure, and not for the benefit of the public." He was sorry the Attorney-General was not present, as the paper would no doubt have had a contrary influence upon him, and have induced him to make some much needed amendments in his Bill.

Mr. Campin pointed out the absence in the Bill of some of the oppressive notions which formerly prevailed. With regard to Clause 19, which required that a patent should be put in operation within three years, such clauses existed in almost all foreign Patent-laws, and they were found to be either oppressive or farcical—farcical because it was easy to set up the apparatus, and call witnesses to prove that it had, therefore, been put in operation, whereas it might be of no more practical use than if it had never been set up at all. No man could tell how soon the public might appreciate his invention, and it might be three or four years before he could get his patent into operation, so that this requisition would be merely granting him a patent with one hand, and taking it away with the other. The compulsory licensing clauses also required a great deal of consideration, and there were a number of minor objections to be dealt with before the Bill could be passed into law with advantage to either inventors or the public; but the main objection to it was that it preserved the existing high scale of charges, and that whatever benefits it bestowed would not apply to old patents. For that, there was no logical reason whatever. The question of Patent-law was of infinite importance to the at present depressed industrial interests of the country, which would be lifted out of that position by nothing so much as by bringing to their aid the ingenuity of inventors, so as to put our industries again in advance of those of other countries.

Mr. St. John Vincent Day thought they had wandered somewhat from the practical features of the question. The Attorney-General was admittedly anxious to do his utmost to bring into operation an equitable Patent-law for inventors and for the nation, but he had apparently lost sight of the fact that they were emerging from the old-fashioned notions on which Patent-laws were framed. Provisions were introduced into the Bill which would unquestionably prove harmful to the proper working of patents. He had known cases in France—where the law required practical operation within two years of the issue of the patent—of valuable inventions, on which thousands of pounds were spent, having been lost on that account. That feature should certainly not be introduced into the Bill, and if the question were properly brought under the notice of the authorities, they would certainly give way. This Bill was the result of several tentative measures which had previously failed in Parliament, not necessarily from disapproval of their scope, but from pressure of other business, and, no doubt, the Bill, as it stood, would give inventors several advantages which they did not now possess, but, on the other hand, it inflicted new disadvantages upon them. He did not consider the tax of £50 in the third year oppressive, as an inventor, unless he had found capital long before that, gave up his invention, as a general rule, altogether. He would, however, prefer to see the tax reduced one half, and removed to the seventh year. Certainly the examination of open documents, in case of opposition, was objectionable. Instead of their being made public, the provision should be for completed documents to be laid before the law officer for the hearing of the opposition. He entirely coincided with the Chairman's remarks with regard to the introduction of inventions from abroad.

Mr. Hale was of opinion that the Government should not place difficulties in the way of patenting inventions; but whether the interests of inventors should be protected after 17 years was a question for consideration. A reduction in the cost of patents would do much to put us on a par with the Americans in the matter of inventions; and he would suggest that a deputation should wait on the Attorney-General, and induce him to reduce the Bill to a shape which would provide for all interests.

Admiral Selwyn said, if they desired to restore the country to her former proud position among the nations of the globe, they must improve the Patent-law, and without that it would be in vain to rely on free trade or anything else. The weariness of the public in the matter simply arose from an utter misunderstanding of

the whole question, because they had been taught to believe there was an antagonism of interests which did not exist between inventors and the public. The Government had always acted on that basis. Even the Act of 1852, which was obtained by the exertions of a few individuals, amongst whom was Sir Henry Cole, caused an enormous increase in the trade and industry of the country, which was almost without parallel, and the voice of Parliament, urged by the constituencies, would be readily listened to again by Government. Tho whole subject should be pressed forward among the constituencies until the public began to understand the question. The only reason why there was a difference of opinion on the subject of fees was because they refused to come to the conclusion they had long arrived at on every cognate subject, that a diminution of impediments was required. Nobody could fail to see that if the fees were made as low as in America ten times as many patents would be taken out as at present. There, 20,000 patents were applied for, and 15,000 granted annually, against 3,000 here. He thought, contrary to what had been expressed by some of the speakers that three or four years were sufficient to develop a patent, that it very often took twelvo or thirteen years to make satisfactory progress with the most important inventions. The Bessemer process, for instance, was not accepted until 12 years after the invention was put forward, and such a fact as that should induce them to endeavour to fence the inventor round with such protection as would induce capitalists to put inventions into operation. The true view of the matter was that it was the capitalist who required protection, and not necessarily the inventor. Twenty-one years was not too long to give those who put their capital at the service of inventors to get a proper usufruct. Long before that the inventor had often disappeared altogether from the scene. There were in the Patent-office hundreds of inventions which had been brought forward before their time, though calculated to be of the greatest benefit to humanity, but they now lay idlo there because they could not be re-patented. Inventors were the prophets of their day, who pointed out the path to material progress, as the prophets of old showed the path in morals, and we were treating our prophets exactly as our forefathers treated the prophets of their time. To show how the question was understood by a kindred nation, he would read an extract from a report of the Senate Committee in America:—"Letters Patent are not to be regarded as monopolies created by the executive authority at the expense of the community, but as public franchises granted to the inventors of new and useful improvements, for the purpose of securing to them, as inventors, for the limited term mentioned, the exclusive right to use their own inventions, as tending to promote the progress of science and the useful arts, and as matter of compensation to the inventors for the labour, toil, and expense of working for the public benefit, as sanctioned by the Constitution and by the laws of Congress." And there was really nothing whatever to lead us to think differently but the word "monopoly," which had been always made a stop-gap to improvement in our Patent-law. The extension to 21 years would be a great boon, but to saddle it with the condition of a further payment of £100 was very unwise. Then the power of amendment was too restricted and vague, and should be made more explicit. The introduction of models was originally an American idea, which the Americans had judged best to put a summary stop to by having a fire. They had told him that, but for the fire, they would not have known what to do with the accumulating models which were blocking up the very passages and staircases, and were rendering it almost impossible to get into the Patent-office, large as it was. In the present advanced state of photography it was quite unnecessary to insist upon such a condition. With regard to the retention of unpaid Commissioners, he entirely concurred in the inadvisability of having any public department so presided over, and these unpaid Commissioners were to be entrusted with the power of making rules which amounted to a general power to legislate. They might, in fact, just as well give the clerks in the Patent-office, who were of course the real working men, that power at once, and they all knew the uncertainty that would produce by making everything depend on the whims of mere temporary officials. One burning question which might be brought forward much more prominently was that of the State user of inventions. It was undesirable that the Treasury officials should be the arbitrators in that matter, and very desirable that inventors should be induced to take their inventions, especially in the case of arms and implements of war, to our own Government, by providing that they should receive a fair reward, to be fixed by experienced persons, in the shape of royalties, as was the case in America. Provisional protection also had given rise to much misunderstanding. It was originally a device by which an inventor, not himself a workman, was protected in getting his invention put into shape by a practical person, and for that purpose he was bound to give the public a description of it if he should perfect it; but gradually the very objectionable practice had sprung up of requiring that he should absolutely define what he was going to patent. An inventor could only give his rough idea, and to say that he should not make any variation or addition to it would be a very bad provision, both for the public and the inventor. As to the time to be granted to foreign and colonial inventors, it was to the interest of every nation to attract to itself every invention useful to mankind. A man who had taken out a patent in Australia could not get one here within the six months of his first protecting himself, and, therefore the time ought to be considerably extended. Again, permission should be given to State servants to patent their inventions. As was stated in the American report, it was positively unjust to prevent them obtaining the same benefit from their inventions as any other inventor would have. If Mr. Anderson's Bill could receive the Attorney-General's careful attention, and if the ideas comprised in it were amalgamated in this measure, the Bill might serve as a stop-gap. As representative on the British Section of the International Congress of Paris, he could assure them that the prevailing idea there was, that the nation which gave the best protection to inventors would take its place in the fore-front of progress, and that by no other means than recognising that an inventor was a benefactor to every State, could true progress be achieved. The Central Committee of Paris, organised by the Minister of Commerce and Agriculture, was making it an international question, and they would say that was one of the finest works the French Republic had ever engaged in. Such a measure would do more real good than all the new-fashioned theories which would teach Capital that Labour was its enemy, and *vice versâ*, because it would cause both inventors and the public to move togethor for the common benefit. He would conclude by moving the adjournment of the meeting, in order that so important a subject might have the benefit of further discussion by those then absent.

The Chairman then put the resolution that the discussion should be adjourned to Tuesday evening, the 20th inst., and it was carried.

The meeting concluded with a vote of thanks to Mr. Lloyd Wise for his paper.

The capital employed in railway undertakings in Great Britain and Ireland is said to be £560,000,000; £1,200,000,000 in America; in Germany, £200,000,000; and in France, £240,000,000.

MISCELLANEOUS.

LOCOMOTION IN JAPAN.

Japan is very unfavourably circumstanced as regards facilities for transport. Its physical conformation is prejudicial to it in two ways. A chain of high mountains, running along its whole length, occupies the centre of the main island, making communication across the country exceedingly difficult, and preventing the formation of any considerable rivers. So effectual is the barrier thus formed, that the produce of the fertile districts on the west coast has to make a circuit of half the island in junks to reach the ports and markets of the east coast. Consul Robertson states that very little has been done by art to remedy these natural disadvantages. There are few good roads in Japan, and still fewer canals. The few large national highways that have been made—such as the Tokaidö, Naka Sendö, and others—were constructed more with a view to administrative and military requirements than for the convenience of commercial transport. They run lengthwise of the island, mostly parallel with the central mountain chain; hence, they are not much used for the transport of goods of great bulk or quantity, owing to the greater cheapness of carriage by sea. Next to these great highways come a class of roads known as "ken" roads, which were originally made by, and for the convenience of, the old feudal daimios and their trains in their journeys to and fro between their own country seats and the capital. They serve principally as feeders of the foot-passenger traffic to the main highways. There is a third class of roads, known as the village roads. These are made at the expense of the villages, for the convenience of communication and transport of produce; but they are, in general, badly designed and ill-made, in many places passing into mere mountain tracks. Narrow and ill-constructed as they are, however, it is by means of these village roads that most of the land transport of the country is carried on. The Central Government is well aware of the necessity that exists for the improvement and extension of these village roads, but it is futile to expect that any substantial amelioration can take place until a considerable reduction is made in the oppressively high rate of land tax, which keeps the bulk of the population of the empire in a state verging upon poverty.

The means of conveyance are in keeping with the character of the roads. Wheeled vehicles are very little used. Horse-carts or waggons are altogether unknown, the only wheeled conveyance being a primitive sort of bullock-waggon. The pack-horse is the usual means of transport all over the country, but bullocks are also used as beasts of burden, especially in the mountainous districts. The principal land carriers company is known as the Tsu-un Kwaisha. Its charges for the conveyance of goods are published in an advertisement sheet, and in addition to the rates stated, there is also a small charge for distribution of the various parcels of goods at their place of destination. If the goods are unusually difficult of carriage, owing to largeness of size and lightness of weight, such as empty boxes, &c., an extra charge of from 10 to 15 per cent. is made. Brittle goods, such as glass, earthenware, &c., are not included in the ordinary rates, and must be separately agreed for. Dangerous articles must be made the subject of special private agreement, otherwise the company will not be responsible. There are two modes of transmitting money from one place to another at present in use. The first is by sending the satsu in a sealed letter or packet. The second is by Post-office orders. The highest amount for which Post-office orders are issued is 30 yen; hence the method of sending the paper money inclosed in a letter is preferred as being the old-established practice. The Post-office statistics, however, show that the money-order system is gradually making its way in popular favour, and as it is much the cheaper method of transmitting small sums, its ultimate predominance over the more primitive method is merely a question of time. Letters containing Post-office orders are sent by the Tsu-un Kwaisha, whether they are received through the Post-office or direct from the sender. The arrangement between the Post-office and the carrying company in respect of this sort of mail matter is not publicly known, but the latter seems to be a close monopoly, and it is believed that no other carrying company would have any chance in competing with it.

The sea-transport of Japan has, until within recent years, been carried on entirely by means of the unwieldy, ark-like, sailing-boats, known to foreigners as junks. The great majority of these are from 700 to 800 koki burden, say 150 tons measurement, but the smaller variety of 200 koki burden is also very common. A small proportion of the largest class range as high as 1,200 koki burden, say 220 tons. The principal articles of junk transport are bulky commodities, such as firewood, rice, charcoal, timber. Osaka is the centre of the junk trade of the empire, especially in the article of rice. There are three principal rice-producing districts in Japan, two of which send their surplus stock in junks to the Osaka market, while the third sends its supplies to Tokio. The rice of the fertile province of Hiogo is accounted the best in Japan. Junks carrying the produce of this region start from Kumamoto, and make the voyage to Osaka, going round by the north of Kiushiu in about twenty days in favourable weather; but in unfavourable weather sometimes double that space of time is required. Other provinces in Kuishiu, namely, Chikuzen, Chikugo, Buzen, and Bugo, also produce large quantities of rice for export to less favoured districts, and a considerable number of the smaller-sized junks are employed in the carrying trade between the coast towns of the eastern side of Kuishiu and Osaka. The voyage up the inland sea occupies from six to eight days. Shimonoseki is the principal way-port for all the rice junks of Kiushiu. The second great rice-producing district of Japan lies in the north-eastern provinces of Echizon, Echigo, Kaga, and Noto. Nügata is the main emporium for the export trade of this region, but a large number of junks also clear from Isuruga. The voyage from Nügata to Osaka is the largest and most difficult in the whole coasting trade of Japan. It occupies an indefinite period, from about ninety days to half a year. The junk starts from Nügata in spring, and sailing round by the southern end of the island, reaches Osaka in the autumn. After reaching Osaka and disposing of their cargoes, the junks usually lie up during the winter, and make the return voyage in the following spring. The third great rice-growing region is in the north-eastern portion of the main island, in what were formerly the provinces of Oshin and Dewa. The rice rupply of Tokio is drawn from thence. The coast between Sendai and Tokio is particularly unfavourable to junk navigation, owing to its want of harbours, and the prevalence of severe gales and mists. There is also a considerable junk traffic between the southern ports of Yezo, principally Hakodate and Matsumai, and the ports on the west coast, Nügata, Noto, and Tsuruga. The large Nügata junks are generally owned by the rich rice merchants, and the following is the arrangement ordinarily made as to remuneration and freight between the owner and master mariner of the junk. The rice merchant loads his junk to four-fifths of its carrying capacity, the remaining fifth being reserved for miscellaneous cargo, which is procured by the captain, and the freight charges of which constitute the captain's remuneration for the voyage, and out of which he pays his crew. The captain shares with the owner

the risk of shipwreck, to the extent of his interest in the freight. There is no such thing as insurance of Japanese junks, but that institution, as administered by foreigners, is appreciated by the Japanese at the open ports.

It is obvious that junks are a tedious, expensive, and highly unsatisfactory means of carrying on the coasting trade of the country, and it is not surprising that, soon after the opening of the country to foreign trade, the daimios, who were then the largest sellers of produce of all kinds, eagerly bought foreign steamers. On the abolition of the han, these steamers were either taken over by the Government, or sold to merchants in liquidation of han debts. Most of the larger class of steamers engaged in the Japanese coasting trade were procured in this way. Those that were subsequently bought by merchants or private companies are, for the most part, of very small size, and are almost entirely confined to the limits of the inland sea. In Kobe there are, at least, half-a-dozen carrying companies owning steamers of this small class. In Yokohama, junk transport has altogether disappeared before the superior facilities afforded, first by small steamers, and afterwards by the railway, for transmission of all kinds of commodities to the capital.

LAND TENURE AND INDUSTRIAL CLASSES IN PERSIA.

Consul Churchill, in his report upon the commerce of Ghilan, thinks it may be interesting to those who know little of the idiosyncrasy of the people of the country, and who yet take some interest in it, to learn something concerning the tenure of land in Ghilan, and the condition of the lower classes in this part of Persia. It is the general belief that the inhabitants of Persia are oppressed by their rulers, and kept down in the scale of civilisation, to the extent that they may well be styled barbarians, by the more favoured nations of Europe, but such is not the case. Public instruction in every town of Persia is strictly attended to, although its aims may not come up to the mark of our notions of education. Almost every child, male or female, in the country is sent to school to learn to read and write, or, at least, to learn to repeat certain favoured passages of the Koran; and the natural intelligence of the children is so vastly superior to that of their brethren in Europe, the development of their intellectual faculties at an early age is so astonishing, that small children will hold their own with grown-up persons, and talk on subjects that would make our little folk of the same age stare with wonder. But, owing mainly to the fact that every book in Persian is a manuscript, and consequently inaccessible to the lower classes on account of its high price, and to the consequence of this circumstance—namely, that few books are ever read by the people—the Persians, as a nation, are what they were 500 years, what we, perhaps, were before the introduction of the printing press in England. To Guttenburg in Germany, and Caxton in England, is to be ascribed the great progress of civilisation in Western Europe, and no country will ever keep pace with the civilising tendencies of the period that does not possess the means of diffusing light amongst it people by this process.

The Persians, altogether a clever and industrious people, capable of imitating almost everything that is produced in Europe, will talk even to this day of the four elements believed in, in the days of Plato—namely, fire, water, air, and earth, and will not be convinced that all such notions have long since been superseded, and proved to be groundless by scientific discoveries. They still cling to the notion that the sun and all the stars revolve round the earth, which they believe to be motionless. With such antiquated ideas, the Shah and his brilliant suite may visit Europe, not once, but half a dozen times, without receiving any benefit therefrom. Saadi and Nizami, Hafiz and Ferdoussi may be very praiseworthy philosophers and poets, but they give very little insight into the best mode of governing and improving a country. Yet the lower classes are far from being miserable. The peasantry are free to till the soil, which in general belongs to the middle and upper classes, and they get an ample portion of the produce of the land for their pains. The middle and upper classes may have become landed proprietors, either by purchase or by inheritance, but they are alone responsible to government for the revenue. The princes and Khans of the empire are appointed by the Shah, as the satraps of olden days, to govern the out-lying provinces in his name.

In Ghilan, one of the richest and most productive districts of Persia, where, on account of its rich vegetation, almost every plant or tree will grow, the lower classes have no reason to be unhappy. Few of them, it is true, possess land, but the arrangements they make with the landowners are all to their advantage. If they engage to clear a piece of jungle, they divide the produce of the land with the owner of the ground. If mulberry trees are planted, the seedlings are purchased by the landowner, and when, after a few years silk, is produced, the peasant rears the worms and get a third of the produce for his trouble, one half of the remainder going to the landowner, and the other half to the speculator who furnishes the silkworm eggs. As little supervision can be at all times exercised over the villager, he naturally contrives to secure for himself a good portion of the crop. The advantages the peasant derives from his agricultural vocation are not inconsiderable. He can cut down wood in the jungle—that is, the neglected part of his landowner's estates—and sell it on his own account. His cows and sheep can browse freely on those parts that are not under cultivation; he can make charcoal without let or hindrance; he can produce vegetables around his hut, and reap all the benefits arising therefrom; he can rear poultry and sell it on his own account; and last, but not least of all, he can dispose of the fruit which grows in abundance on the estate without consulting the owner of the land. The principal profits of the latter are his portion of the silk crop, the value of the mulberry leaf when sold, and his share of the rice produced on the estate. He also gets, out of courtesy, the first fruits of the land brought to him as an offering by his tenants. When the silk crop fails, the burthen falls principally on the landowner, who has to pay the land-tax assessed years ago, irrespective of what the land may now produce. The peasantry and speculator, together with the landowner, lose their profits.

The taxes are not farmed out in Persia as they are in the Ottoman Empire, and the officers employed by Government in collecting the revenue are not, as a rule, exacting. Here and there cases do occur in which complaints are made to the superior authorities, but they do not constitute a system of oppression. As a matter of course, in collecting the maliat (taxes), the collectors contrive to extract from the taxpayers some 10 or 20 per cent. more than they are entitled to, but so long as they do not exceed these limits, everybody feels satisfied. When the tax-gatherer grows rich, he is pounced upon by the governor, who makes him disgorge. In his turn the governor is called upon by the Shah, either to pay large presents on his appointment, or heavy fines for reported malversations. The revenue in Ghilan is collected one-half towards the end of August, by which time the silk crop, which constitutes the principal produce of the district, has been brought to maturity; the other half is collected towards the end of the financial year.

In India it has been calculated that the income of the native peasantry is on an average £2 a year. In Ghilan it is no less than £5 to £9. The principal food of the peasantry is rice, of which they produce an abundance, of a very fair quality, and at a very low price. The

women are mostly employed in the cultivation of this grain. Meat is cheap, 3d. being paid per pound for mutton, and 1½d. for beef. The clothing of the villagers in summer is scanty, consisting in dyed cotton wares and no shoe leather; in winter he wears a homespun woollen cloth of a very coarse but substantial quality; his wants are few, he is sober, and in most cases industrious. Towards the beginning of winter the natives of Khal-Khal, a mountainous region near Ardabil, in the province of Azerbijan, have from time immemorial been in the habit of quitting their lofty plateau to come down into the plains of Ghilan, to seek employment as well as shelter from the inclemency of the cold season. Their rendezvous is the town of Resht, where they are engaged by contract to till the surrounding country.

Some of them thus found their way to the confines of Mazenderan. In some years 15,000, in others as many as 25,000 individuals are thus employed. In coming down from the mountains they carry all they posses in a bundle, which they suspend at the end of a stick. In the towns they collect in the numerous tekkehs erected by the wealthy portion of the population for the performance of their religious theatricals in the month of Moharrem. There is very little skilled labour to be met with amongst them, the utmost they profess to do is to turn up the soil, to dig trenches, and to saw down trees. Their wages are, on an average, 3d. a day, but they are entitled to rations and other advantages which, in money value, make up an income of 6d. a day. After four or five months' labour on these conditions, they return to their homes, where the snow has melted and the soil is fit for cultivation. Their savings do not amount to much. From 10s. to 20s. is the utmost they can put by, and this is usually invested in the purchase of cotton wares for the use of their wives and children, but they have enjoyed a mild winter compared with their own, whereas at home they would have been exposed to all the miseries attending intense cold, and that without occupation.

The peasant is far superior in courage to the townsman, who, it must be owned, has gained the reputation of pusillanimity. In summer, you often see the villagers wrestling amongst themselves, while in winter, they hunt the wild boar with dogs, and no other weapon than a short spear. It is remarkable what little crime there is in this part of Persia; seldom does one hear of murder or robbery. A traveller may go from one end of the province to the other without any danger of being robbed. The doors of a house may remain open all night with impunity. Infanticide is a thing unknown in the country. And these virtues may be attributed to the mildness of the climate, which necessitates little exertion to procure a sufficiency of shelter, food, and covering. A single day's labour is sufficient for all the wants of an individual during a whole week. Mendicity is little known, and, with the exception of cripples and blind, very few mendicants are to be seen in the towns, and their lot does not appear to be a very hard one, as they receive ample charity from the inhabitants.

CORRESPONDENCE.

"POSTING PROOFS."

I venture to make a very short suggestion in reply to the article in a recent number of the *Journal* on "Posting Proofs." It is this, that if every post-office had fastened to the counter one of the machines now used by railways to date their tickets with, having, in addition to the date, the hours of each time for posting (altered from time to time), anyone could go and stamp his own letter, and thus all unnecessary employment of officials would be saved.

The only addition to the above that would be required would be that it should be incised in the left-hand corner of the envelope, not printed. G. M. NECKS.

51, Rutland-gate, April 20th, 1879.

AFRICAN RAILWAYS.

I regret to see that in Mr. Fell's paper, as published, he has not thought proper to withdraw what is really an imputation upon my personal veracity, made by him in his concluding remarks, though I afforded him every opportunity of retracting his mistake before going to press. My version of the facts differs materially from Mr. Fell's. I find that he did not write to the Yorkshire Engine Company himself, but made an application through a third person with reference to the cost of construction of some Italian line, of which neither the plans or sections were attached.

Very properly, this application was referred to me, since, firstly, the Yorkshire Engine Company are not railway contractors, and, secondly, they cannot take orders for Pioneer rolling stock, except through me. Mr. Fell best knows why the reference has not been made to me.

If Mr. Fell really believes my system to be better than his own—else, why give it the preference in Italy, and why acknowledge that his system is, as regards grades, even more wasteful than the ordinary railway—he can give an order to-morrow through me to the Yorkshire Engine Company, whose written guarantee I hold for the construction of machinery capable of propelling a train load of 200 tons up 1 in 20, a miracle to Mr. Fell, whose net load at Aldershot was only 14 tons up 1 in 50, or equal to a gross load of 4 tons on 1 in 50, the weight per axle being in both cases identical, and, therefore, the comparison a just one. Nothing can more clearly demonstrate the difference between my system and those of my predecessors than Mr. Fell's scepticism upon the matter, as he professes to have tried all I have done and failed, as he did upon the Mont Cenis, because he did not understand that driving is akin to brakeing, and that an excess of grip meant a brake; a rather unusual application on ascending inclines, and, therefore, hardly to be expected to realise a profit. J. L. HADDAN.

25, Great George-street West,
6th May, 1879.

A TEST FOR ENAMELLED IRON.

I have read with much interest the paper and discussion on M. Dodé's method of preserving and ornamenting iron, and am sorry that I could not attend when the paper was read.

My object in writing now, is to communicate a method of testing such coatings of iron, which I applied some years ago in Birmingham, when consulted by Messrs. Griffiths and Browett, as to the value of a patented process of enamelling. After trying the usual tests of heat and acids, I immersed some of the vessels (evaporating dishes) in a solution of sulphate of copper, and left them in the solution for 8 or 10 hours. This found out their weak places with cruel severity. Little beads of copper grew over pin-holes otherwise invisible, and on the edges where the white inside and blue outside enamels were not in perfect contact.

If M. Dodé's platinised or enamelled iron will stand this test, it must indeed be excellent. I have not had an opportunity of trying it.

It may be useful as a preliminary or working test for the best work, where extra precaution is demanded, as it will find out any pin-holes, and thereby show whether a second treatment is demanded.

W. MATTIEU WILLIAMS.

Belmont, Twickenham, May 1.

NOTES ON BOOKS.

Life of Robert Stephenson, Civil Engineer. By David Stevenson. Edinburgh: A. & C. Black.

This biography of an eminent civil engineer contains a full record of his labours, during a long life, in many branches of his profession. Mr. Stevenson was born in the year 1772, and at the early age of nineteen was entrusted with the erection of a lighthouse on the island of Little Cumbrae, in the River Clyde, shortly after the constitution of the Board of Northern Lighthouses. Having had considerable experience in this important branch of his profession, he was appointed engineer to the Board in 1798, an office which he held for a long period. In the following year, he first conceived the idea of his great work, the Bell Rock Lighthouse, formed on Smeaton's Edystone, with certain improvements. In 1811, the lighthouse was completed, and a more satisfactory warning to mariners was thus placed on the Inchcape Rock than the Abbot of Aberbrothock's bell, so famous from Southey's ballad. The erection of this lighthouse was by no means Mr. Stevenson's only claim to fame. The other works undertaken during his valuable career were connected with harbours, rivers, roads, railways, ferries, and bridges, all which subjects are fully described by the author of the life. To Stevenson the beautiful city of Edinburgh owes much, for it was he who designed the approach from the east by the Regent and London roads, and opened up a handsome access to the Calton-hill.

The Magazine of Art. Parts 1 to 13. London: Cassell, Petter, and Galpin.

A fully illustrated journal, which contains a varied series of papers on subjects connected with the Fine Arts. There are papers on artists' haunts (such as Cornwall and Sark), on exhibitions, notices of living artists, and bits of art news.

OBITUARY.

Thomas Wills, F.C.S.—Many members of this Society will have heard with regret of the very sudden death of Mr. Thomas Wills, who has acted as Secretary to the Chemical Section of this Society since it was first founded in 1874. Mr. Wills was born in 1850, in Devonshire; he was educated at University College School and at King's College. In the early part of 1868 he became an assistant to Dr. Odling at St. Bartholomew's Hospital, and in the latter part of that year, on Dr. Odling being elected to the Fullerian professorship at the Royal Institution, Mr. Wills was appointed his official assistant. In 1873 he resigned this post to accept the position of Demonstrator in Chemistry at the Royal Naval College, and in the following year he became connected with this Society. Mr. Wills had already made considerable reputation as a chemist. The subject to which he specially devoted himself was the application of chemistry to the manufacture of gas, and on questions connected with this subject, he was rapidly becoming an authority. He held for some time the position of chemist to the Phœnix Gas Company. In 1873, previous to his official connection with the Society, he read a paper on "The Manufacture of Gas," and last year he gave a short course of lectures before the Society on "Explosions in Coal Mines," which were published in the last volume of the *Journal*. For both the paper and the lectures he received the Society's Medal. He was also a constant contributor to the Transactions of the Chemical and other societies. For several years he acted as Secretary to Section B. (Chemistry) of the British Association, and he was a member of the Association Committee for ascertaining the best methods of improving the illuminating power of coal gas. His most recent piece of work was in connection with the subject of electric lighting. Dr. Tyndall, in giving evidence upon the electric light before a Committee of the House of Commons, referred to Mr. Wills as having discovered that oxides of nitrogen were given off by the voltaic arc, thus rendering the light to that extent injurious. His death was most sudden and unexpected. He fell a victim to typhoid fever, which carried him off after an illness of less than a week. He was only 28 years of age at the time of his death. His many friends will feel with sorrow the sudden blow which thus prematurely cut off a life so full of promise of future useful work.

GENERAL NOTES.

Cost of Singing in Elementary Schools.—Sir Charles Dilke has lately obtained a return (No. 142, price one halfpenny) from the Education Department, showing what the annual cost of "singing" in elementary schools is, which Mr. Hullah, the inspector, for years has reported in vain to "My Lords" to be, musically, worse than useless. It is the first time the great expense comes before Parliament. The 15,077 schools connected with the National Society or Church of England received grants amounting to £67,632 5s., whilst 47 were disqualified and 91 not taught. The 1,941 British and undenominational schools received £11,604 8s., whilst three were disqualified, and 15 not taught. The 819 Wesleyan schools received £5,855 8s., all taught and none disqualified. 1,167 Roman Catholic schools received £6,288, only one disqualified, and four not taught. The 4,428 Board Schools received £27,749 17s., whilst 10 were disqualified, and 15 not taught. Thus the best "singing" schools were the Wesleyans, which earned the highest grant and had no failures. The School Board schools come next. The inspectors are the judges of what "singing" is.

Street Lighting by Gas.—We recently illustrated and described the new burners and lamps with which Waterloo-road, Lambeth, and Waterloo-place, Regent-street, are lighted. Queen Victoria-street is now similarly lighted, and the three experiments have given some useful information respecting the value of cannel and common coal gas, as showing that it does not much matter whether cannel gas or ordinary gas be used so that it be properly burnt. It will be remembered that in Waterloo-place cannel gas is used, the price of which is 4s. 4d. per 1,000 cubic feet. In Queen Victoria-street lighting, there are 30 80-candle burners, each consuming 22 ft. per hour, which equals 600 ft., giving an illuminating power of 2,400 candles, and five 200-candle burners, each consuming 50 ft. per hour, which equals 250 ft., or 1,000 candles. The totals are 910 ft. of gas per hour, giving a light equal to 3,400 candles. The cost of this gas for the entire length of street lighted is, at 3s. 6d. per 1,000 ft., 38·22d., or a light of 88·95 candles for 1d. per hour. In Waterloo-place there are 43 80-candle burners, each consuming 19 ft. per hour, which equals 837 ft. or 3,440 candles, and two 200-candle burners, each consuming 45 ft. per hour, which equals 90 ft. or 400 candles. The totals here are 927 ft. of gas per hour, and a light equal to 3,840 candles. The cost of the gas at 4s. 4d. per 1,000 ft. is 3s. 7½d. per hour for the whole number of lamps, or a light of 88·24-candles for 1d. per hour. It will thus be seen that the lighting with common gas at 3s. 6d. per 1,000 ft. is slightly superior to that with cannel gas at 4s. 4d. per 1,000 ft. It therefore follows that if the gas be burnt properly, it is of little consequence whether cannel or common gas is used, the cost being practically the same for the same illuminating power, as roughly tested by judging the comparative efficiency of the illumination.—*Engineer*.

African Exploration.—*Nature* states that there seems every likelihood that an attempt will be made to train African elephants as bearers of burdens, and indeed it is stated that an association has been formed for the opening up of African trade by this means. This seems to us a much more sensible and practicable plan than the construction of a railway, which has been so prematurely proposed in some quarters. With the aid at first of Indian trainers we see no reason why the African elephant should not be made as useful as his Indian brother.

NOTICES.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

May 14.—"The Automatic Hydraulic Brake." By E. D. Barker, Esq. Capt. Douglas Galton, C.B., LL.D., F.R.S., will preside.

May 21.—"Edison's New Telephone." By Conrad W. Cooke, Esq. Prof. J. Tyndall, LL.D., F.R.S., will preside. [See notice on page 497.]

African Section.

Tuesday Evening, at Eight o'clock.

May 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society. Arthur Mills, Esq., M.P., will preside.

Chemical Section.

Thursday Evening, at Eight o'clock.

May 22.—"The History of Alizarine and Allied Colouring Matters, and their production from Coal Tar." By W. H. Perkin, Esq., F.R.S. Part II.

The date for the reading of this paper will be May 22, not May 15, as previously announced.

Indian Section.

Friday Evening, at Eight o'clock.

May 23.—"The Harbour of Kurachee." By W. J. Price, Esq., M.I.C.E. Sir William Merewether, C.B., K.C.S.I., will preside.

Cantor Lectures.

Third Course: Five Lectures by W. H. Preece, Esq., on "Recent Advances in Telegraphy."

Lecture IV.—May 12.

Duplex, quadruplex, multiplex, and harmonic telegraphy.

Lecture V.—May 19.

Automatic and fast-speed telegraphy.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. W. H. Preece, "Recent Advances in Telegraphy." (Lecture IV.)
Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. Resumed discussion on Dr. Sturge's Paper, "The Disposal of the Sewage of Paris."
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. Professor G. Rolleston, "The Modifications of the External Aspects of Organic Nature produced by Man's Interference."

Tues....Royal Institution, Albemarle-street, W., 3 p.m. Prof. Karl Hillebrand, "The Intellectual Movement of Germany from the Middle of the Last to the Middle of the Present Century." (Lecture I.)
Royal Horticultural, South Kensington, S.W., 1 p.m.
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. 1. Discussion, "Street Carriage-way Pavements;" and, time permitting, 2. Mr. I. P. Griffith, "The Improvement of Dublin Bar by Artificial Scour."
Photographic, 5a, Pall-mall East, S.W., 8 p.m. Mr. C. Bennett, "The Gelatine Emulsion Process."
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Mr. Hyde Clarke, "Ethnology, Mythology, and Philology of Races of Early Culture; Babylonians, Etruscans, Egyptians, Japanese, &c." 2. Mr. A. L. Lewis, "Notes on some Irish Affinities." 3. Mr. A. Wylie, "History of the South Western Barbarians." (Translated from the Chinese.) 4. Mr. H. H. Howorth, "The Spread of the Slaves," Parts 2 and 3, Sections 1 and 2.

Wed....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. E. D. Barker, "The Automatic Hydraulic Brake."
Geological, Burlington-house, W., 8 p.m. 1. Prof. T. McK. Hughes, "The Pre-Cambrian Rocks of Caernarvonshire." 2. Mr. A. Champernowne and Mr. W. A. E. Ussher, "Notes on the Structure of the Palæozoic Districts of West Somerset." 3. Mr. C. T. Clough, "The Whin Sill of Teesdale as an Assimilator of the Surrounding Beds." 4. Senor Calderon, "The Augitic Rocks of the Canary Islands." Communicated by the President.
Microscopical, King's College, W.C., 8 p.m. 1. Mr. A. Wm. Waters, "The Occurrence of Recent Heteropora." 2. Mr. A. Grunow, "New Species and Varieties of Diatomaceæ from the Caspian Sea."
Society of Telegraph Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Lieut.-Col. Bolton, "Some Historical Notes on the Electric Light."
Church of England Temperance Society (at the House of the Society of Arts), 2.30 p.m.

Thurs...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 11 a.m. (Annual Sanitary Conference.) Opening of the proceedings by the Chairman. Papers and discussions.
Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Chemical, Burlington-house, W., 8 p.m. 1. Mr. R. Warington, "Nitrification." (Part II.) 2. Dr. Wright and Mr. Luff, "Alkaloids of the Veratrums." (Part III.) 3. Dr. Wright, "Alkaloids of the Veratrums." (Part IV.) 4. Dr. Wright and Mr. Luff, "Alkaloids of the Aconites" (Part IV.), and "Japanese Aconite Roots." 5. Mr. S. Pickering, "The Action of Hydrochloric Acid on Manganese Dioxide." 6. Mr. A. W. Blythe, "The Composition of Milk in Health and Disease." 7. Mr. W. H. Watson, "Notes on the Effect of Alcohol on the Chemistry of Digestion."
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. E. P. Loftus Brock, "The Uses of a Collection of Ancient Engravings." (Illustrated by Examples of the various Schools and Periods.)
Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "Dissociation." (Lecture III.)
Numismatic, 4, St. Martin's-place, W.C., 7 p.m.
Royal Society Club, Willis's-rooms, St. James's, S.W., 6 p.m.

Fri......**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 11 a.m. (Annual Sanitary Conference.) Papers and discussions continued.
National Indian Association, Langham-hall, 43, Great Portland-street, W., 8 p.m. Mr. Robert N. Cust, "Caste."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. A Cornu, "Etude Optique de l'Elasticité." (In French.)
Philological, University College, W.C., 8 p.m. Anniversary. President's Annual Address, by Mr. James A. H. Murray.

Sat.....Royal Institution, Albemarle-street, W., 3 p.m. Mr. H. H. Statham, "The Leading Styles of Architecture Historically and Æsthetically Considered." (Lecture IV.)

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,382. Vol. XXVII.

FRIDAY, MAY 16, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

The Fourth Lecture of the Third Course of Cantor Lectures, on "Recent Advances in Telegraphy," was delivered on Monday, the 12th inst., by Mr. W. H. Preece.

The lecture dealt with duplex, quadruplex, and multiplex telegraphy. Instruments in the room were connected with the General Post-office, and messages on the duplex and quadruplex systems were sent to and fro during the lecture, two and four messages passing simultaneously over the single wires.

The Lectures will appear in the *Journal* during the summer vacation.

EDISON'S TELEPHONE.

At the Ordinary Meeting of the 21st May, a paper will be read on "Edison's New Telephone," by Mr. Conrad W. Cooke; Professor J. Tyndall, LL.D., F.R.S., in the chair. On this occasion the usual rules for the admission of Members and their friends will be suspended. Admission will be by tickets only, and no person, whether a Member or not, will be admitted without a ticket. The tickets have now nearly all been issued, and only a very few more applications can be received.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference on National Water Supply, Sewage and Health, was held in the Rooms of the Society of Arts, yesterday and to-day, at eleven o'clock. At the morning sitting the chair was taken by Lord Alfred Churchill, the Chairman of the Council, in the absence of the Right Hon. James Stansfeld, M.P., late President of the Local Government Board, who was prevented by indisposition from attending. During the afternoon, however, Mr. Stansfeld himself was able to preside.

The following is a list of papers to be read at the Conference:—

Methods of Securing a Sufficient Supply of Pure Water.

Brown (A. H.), M.P., "The Incidence of Rating for Sanitary Purposes in Rural Districts."

Conder (Francis B.), C.E., "On the Utilisation of the Water Supply of England."

Wheeler (W. H.), M.Inst.C.E., "The Water Supply of Rural Districts."

Clutterbuck (Rev. James C.), "The Water Supply of Large Towns."

De Rance (C. E.) F.G.S., "Pervious Rocks of England and Wales."

Hull (Professor Edward), LL.D., F.R.S., "On the Underground Water Supply of Villages, Hamlets, and Country Parishes, of the Central and Eastern Counties of England."

Lucas (Joseph, F.G.S.), "Watershed Lines; Subterranean Water-ridges."

Prestwich (Joseph), F.R.S., "National Water Supply."

Ansted (Prof. D. T.), M.A., F.R.S., "River Conservancy."

Denison (Ven. Archdeacon G. A.), "Supply and Storage of Pure Drinking Water, East Brent, Somerset."

Dillon (James), "On the Effects of Under and Arterial Drainage on Rivers and Floods."

Hawkshaw (J. Clarke), "River Conservancy, Illustrated by Drainage Administration in Holland."

Lynam (James), C.E., "The Sanitary State of the Valley of the River Shannon referred to bad regulating Weirs."

Smyth (John), jun., C.E., "On the Water Supply of the Upper Bann River, Ireland, and the amount of Rainfall Utilised."

Denton (J. Bailey), "National Water Supply; Domestic Filtration of Water Conserved in Tanks and Cisterns."

Foote (G.), Medical Officer of Health, "The Water Supply of Kington and Neighbourhood."

Slagg (Charles), C.E., "Suggestions of a State Record of the Surplus Water flowing from High and Uncultivated Lands."

Sutcliff (Robert) "Abyssinian Tube Wells.'

Evils of Impurity, and Consequent Connection of the Question of Water Supply and Sewage.

Brown (John, L.R.C.P.), "Remarks on some of the Diseases due to Sewer-gas Poisoning."

Hart (Ernest), "Epidemics produced by Polluted Water Supply."

Thorne (R. Thorne), M.D., "The Recent Outbreak of Enteric Fever at Caterham."

Methods of Sewage, &c.

Cole (Sir Henry, K.C.B.), "Progress with Sewage since the first Congress of the Society of Arts in 1876, submitted to the fourth Congress in 1879.

Cresswell (C. N.), "The Thames and its Tributaries."

Chadwick (Edwin), C.B., "Course of Inquiry as to Works of Sanitation, and as to their Expense and Results."

Latham (Baldwin), C.E., "Works of Sewage and Sewage Disposal—Croydon Sanitary Authority."

Cole (Granville), Ph.D., "Some Experiences of Sewage Effluents, and Burning Sludge into Cement."

Hillé (F.), "Ten Years' Practical Experience in Sewage Treatment."

Jones (Lieut.-Col. Alfred S.), V.C., "Sewage Disposal at Wrexham."

Masters (Henry), "The Double Check System of House Drainage."

Banner (E. G.), "House Drainage." The Banner System of House Sanitation.

Morrell (Conyers), "Cinder-sifting Ash-closets."

Seaton (Edward), M.D., "On the Substitution of the Pail System for the Privy Midden System in Nottingham, and its Effects in Reducing the Mortality and Sickness from Enteric and Continued Fevers."

Sturge (W. Allen), M.D., "Sewage Irrigation in Paris."
Winton (John G.), "The Ventilation of Sewers."

At the close of the discussion on Friday, the following resolution was passed:—

"That this Conference wishes to express its entire satisfaction at the action taken by His Royal Highness the Prince of Wales, President of the Society, in applying to the Government for the appointment of a Royal Commission to inquire into the Water Supply of the country, and earnestly hopes that the Government will take steps without any delay to carry into effect the resolutions passed at the meeting held last year."

A full account of the proceedings of the Conference will appear in the *Journal*.

PRACTICAL EXAMINATIONS IN MUSIC.

An examination for candidates residing in or near London has been arranged to be held at the House of the Society of Arts, during the week beginning June 16.

The examinations will be exclusively practical, and will take account of voice, style, ear, and reading.

Candidates in vocal music will be required—

1. To sing a solo, or to take part with another candidate in a duet, already studied. Credit will be given for the choice of the piece sung.

2. The pitch of a key-note being given, to name sounds or succession of sounds, played or sung by the examiner in that key and in the keys connected with it; *e.g.*, the dominant, subdominant, relative minor, or other.

3. To sing or solfa at sight passages selected generally from classical music.

Candidates in instrumental music will be required—

1. To play a piece already studied. Credit will be given for the choice of the piece played.

2. The pitch of a key-note being given, to name sounds, played by the examiner in succession or in combination, in that and its relative keys.

3. To play a piece or portion of a piece at sight.

The maximum of marks is 100. These will be distributed among the subjects of examination in the following proportion:—

Vocal Music.

Voice	20	per cent.
Style	20	,,
Ear	20	,,
Reading	40	,,

Instrumental Music.

Execution	20	per cent.
Style	20	,,
Ear	20	,,
Reading	40	,,

Candidates who obtain 75 marks will be entitled to a first-class certificate; and those who obtain 50 to a second. Candidates, the number of whose marks is below 30, will be entered as "not passed."

Before admission to the examination all candidates must have sent in a certificate, from a professor or other musical authority, to the effect that their qualifications are such as to afford a reasonable chance of their passing. Vocal candidates must come provided with a second copy of the solo or duet they have studied, in the established notation.

An accompanyist will attend the examination for vocal music, but candidates who prefer to do so, can bring an accompanyist with them.

Each candidate must pay a fee of 5s.

The examination will take place in the day or evening, according to the convenience of each candidate.

Intending candidates should at once communicate with the Secretary of the Society, stating if they desire to attend during the day or in the evening. They will then receive due notice of the day and hour fixed for their attendance.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 14th, 1879; Captain Douglas Galton, C.B., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Davis, Frederick William, 6, Duke-street, Adelphi, W.C.
Holland, Walter, Mayor of Worcester.
Law, Henry, 5, Queen Anne's-gate, S.W.
Owen, Henry, 16, Sussex-place, Brompton, S.W., and 114, Marlborough-road, S.W.
Phillips, John, Aller Pottery, near Newton Abbott, Devon.

And as an Honorary Corresponding Member:—

Alvear y Lara, His Excellency Don Francisco, G.C.I.C., Havana, Cuba.

The following candidates were balloted for and duly elected members of the Society:—

Ancketil, Maxwell, Warwick-road, Kensington, W.
Evans, Richard, 10, Bank-square, Chepstow.
Grain, J. H., Virnew-house, Lewisham-hill, S.E.
Griffith, Acton F., 2, St. Stephen's-villas, Shepherd's-bush, W.
Iliffe, William, Hartington-street, Derby.
Inch, Robert Higgs, Town-hall, Lowestoft.
Muter, John, Ph.D., F.C.S., Winchester-house, Kennington-road, S.E.
Newsome, W., Newcastle-on-Tyne.
Nichols, George Benjamin, Handsworth, Birmingham.
Preen, Harvey, Comberton-road, Kidderminster.

The paper read was—

HYDRAULIC AUTOMATIC BRAKES.

By E. D. Barker.

Before proceeding to explain the mechanical details I employ for working brakes by hydraulic power, I would commence by calling attention to the fact that, although brakes have been actuated by mechanical means, by steam, by compressed air, vacuum, and electricity, my own system may be said to have been the only one using hydraulic power that has gone beyond the experimental stage. The reason for this it is rather difficult to find. For a variety of purposes, such as lifts, hoists, compressing machines, dock gates, Armstrong cranes, Tweddle's rivetting machines, and various other purposes, no one would think of calling in question the extreme applicability of water. The work required to be done in the case of railway brakes, viz., a great force exerted through a short distance on the brake blocks of the train, presents a very strong analogy to the usual purposes for which hydraulic power is used. Supposing no insuperable objection exists, would not water be the medium any engineer would naturally select? I will, therefore, call your attention to the great suitability of water to accomplish all that is required in a brake, and the advantages inherent in it, laying great stress on these points; then, on the broad ground that if water be unsuitable, perfecting details, to obtain necessary results, is time wasted. I hope, therefore, to convincingly show that water gives advantages, possessed by no other medium, and I will afterwards explain the mechanical arrangements for enabling hydraulic power to actuate railway brakes.

All fluid brakes depend for their efficiency upon the pipes and fittings being kept tight. Water swells leather, working surfaces keep tight under the highest pressures, and hydraulic joints are easily made. Another material advantage—any leak is visible, and can be at once detected. Who has not experienced the difficulty of tracing a leak in the suction pipe of a pump? And it may be broadly stated that time is not consumed so much in stopping a leak, as in finding it out. Too much stress can scarcely be laid upon this point; it is one that will at once recommend itself to all practical men. It is the almost invisible flaws in various working parts, such as are the constant source of anxiety to locomotive foremen. Water brakes must necessarily give evidence automatically when they leak, or are out of order; this with other fluid brakes is impossible. Any gas engineer present will appreciate the value of leaks being easily detected; were it not for the smell of gas escaping, detection would be almost impossible; and with rolling stock in nearly constant movement, the difficulty of detecting leakage, before it gives rise to trouble, and inefficiency of the brakes, is increased tenfold. I would, therefore, call special attention to this point, which has been somewhat overlooked. Water enables the power to be applied direct, dispensing with levers and gearing. No inconvenience arises from frost, for the simple and cheap admixture of common salt prevents the water from freezing, and maintains the brakes in full efficiency during the severest weather. Water being incompressible, and the pipes and cylinders being always charged with it, the water-pressure can be transmitted, with lightning rapidity, through the train. Though the application of the brakes is instantaneous, the hydraulic power gives a power grip, rather than a blow, and the value of this, as regards wear and tear, will be obvious.

Before commencing a description of the apparatus, I would briefly allude to a circumstance to which is partly, if not wholly, due the fact that at the present moment, not more trains are fitted with my system. Owing to considerable difficulties experienced with donkey pumps generally, and those working brakes in particular, I endeavoured, by way of experiment, to fit up an arrangement of brake in which the accumulator was charged without the aid of a force pump. I had grave misgivings at the time as to its success, and as this experiment inopportunely was made just at the time the Newark trials were instituted, it was due to the failure of this experiment alone that such mediocre results were then obtained. After this I was permitted to apply a steam donkey pump, of my own design, to charge the accumulator, which has proved itself not only perfectly reliable, but has been working for upwards of a period of three years without giving any trouble.

In commencing the description of the Automatic Hydraulic Brake, I would call attention to the fact, that it may be regarded in the light of an addition to the Direct Hydraulic Continuous Brake, in use on the Midland Railway, whereby in case of a break away, or derangement of pipes, &c., the brake has been made self-applying, and for this purpose each carriage, as a matter of course, carries its own separate auxiliary accumulator, and it is so arranged that the brakes can be applied either by force of water stored up in a large accumulator fixed under the foot-plate of the engine, or by the force of water stored up in small auxiliary accumulators under each carriage. To do this there are two distinct lines of pipes. The automatic pipes, which are very small, are also in duplicate, and the whole is so arranged, that whatever occurs, the train has never to complete the journey without the aid of efficient brake power. From the above it might appear to be a complication of pipes, but an inspection of the train in question would remove any such impression, and these arrangements permit of results being obtained impossible in any other way. It may, however, be interesting to explain the mechanical details before proceeding further.

There is a large accumulator under the foot-plate of the engine, with the pump attached. This pump draws the water from a separate tank on the tender, holding about 60 gallons, and forces it into the accumulator. At the end of the accumulator steam is admitted, and the steam-piston, which is 15 inches in diameter, is larger than the accumulator water-piston, which is 10 inches only in diameter. Steam is always acting against the steam piston, and the pump forces water in, and drives the steam-piston to the bottom of its stroke against the pressure of the steam, which performs the part of a weight in an ordinary accumulator.

The steam that works the donkey pump is taken from the steam end of the accumulator. In the piston-head a valve is arranged, which cuts off steam automatically from the donkey pump, so

soon as the steam-piston is forced to the bottom of its stroke, and the accumulator is fully charged. From this accumulator the water under pressure is led by pipes, which are purposely very small through the train; the object of these pipes is to charge the automatic auxiliary accumulator under each carriage. Another larger pipe conveys the water under pressure through a regulator, an arrangement of reducing valve, and thence by pipes through the trains.

These larger pipes convey water under pressure to the brake cylinders, by means of which the brakes are actuated. The regulator alluded to is an arrangement, by means of which the hydraulic pressure, acting on the brake blocks, can be increased or diminished at the will of the driver. There are two valves; the office of one valve, which is partly balanced by a ram, is to admit water under pressure, the spindle of which is provided with a piston; so soon as there is any water pressure in the brake pipes, it exerts its force against the small piston, and closes the valve, so that, as more pressure is required in the brake pipes, so more force has to be exerted to lift this valve. The other is a release valve, and acts like a safety valve; as the pressure is increased on the valve, so it permits more pressure in the brake pipes, and as the force on this valve is diminished, it allows the water to escape. To release the brakes, this valve is lifted, permitting the water to escape back to the tank. These valves are so arranged that, by moving a lever backward or forward, the force acting on these valves is increased or diminished, and in this way the pressure in the brake pipes can be regulated with the utmost delicacy from 20 lbs. to the square inch to 350 lbs. to the square inch. To apply, therefore, the brakes on the direct plan, the driver allows water to pass through this regulator valve, just explained, to small brake cylinders under each carriage, by means of which the brakes are operated.

Water is conveyed by flexible tubes to the end of a cylinder, forces out a piston and ram, which are connected to one brake block, while the cylinder is connected by rods to the brake block on the other side of the wheel; the cylinder, by a retrograde movement, draws this brake block on to the wheel. They are thus gripped between two blocks. On consideration it will be evident, by this mode of applying the hydraulic power, that the whole strain is thrown on the periphery of the wheel and nowhere else, and any unequal wear of the blocks will not affect this result, the power being applied direct. In this way, cross shaft and levers are dispensed with, and the rams, having sufficient stroke to wear out the brake blocks, the attention and supervision connected with taking up of the brake blocks is not required, as with some systems. The automatic accumulators under each carriage consist of a chamber containing a valve and a small ram by which this valve is moved. This chamber is connected by pipes to the brake cylinders. Water has to pass through this chamber, whether the brakes are applied on the direct system or automatically. In addition to this, there is a cylinder containing a long ram, four inches diameter by six-inch stroke, loaded with powerful springs, the large spring exerting a force of 30 cwt. The small ram is also loaded with a spring, exerting a force of 400 pounds. Water, under pressure, is conveyed to these ram-chambers by small automatic pipes, from the large accumulator under the foot-plate of the engine, as before explained. The water acts on the smaller ram, forcing it to the end of its stroke, and with it the valve shown, and thence is conveyed by a small pipe to act against the larger rams, which it forces to the end of its stroke, against the power of the 30 cwt. spring.

The water passes a valve, so that on the breakage of the automatic pipes, the water is prevented from escaping from the large ram cylinder; the water, however, escapes from the small ram cylinder, and the spring with which it is loaded, forces it to the bottom of its stroke, and in doing so moves the valve; this valve, thus being moved, uncovers a port, which allows the water to pass from the large ram chamber to the small chamber in which the valve works. This chamber is connected, as previously stated, by a pipe to the brake cylinder, the water under pressure passes to the brake cylinder, and the brakes are thus applied automatically, namely, by the breaking of the automatic pipes, as explained. So long as the automatic pipes are not broken, the ram is at the end of its stroke, and its spring compressed, and the valve covers the port leading to the large ram chamber. It will be seen, however that another port is uncovered; this port is in connection with the ordinary main water-pipes, and so long as the valve is in this position, by admitting water under pressure into these pipes, it passes from the valve chambers and acts on the brake cylinders, the only difference being in one case—water under pressure is obtained from the small auxiliary automatic accumulator, and in the other case from the large accumulator under the foot-plate of the engine. The water pressure in the latter case being derived from one source, and passing through the regulating valve, the hydraulic pressure acting on the several brake blocks, can be regulated at will in a more perfect manner than in any other way.

I will pass on now to describe the coupling of the pipes between the carriages, a point upon which the efficiency of a brake depends. It will be evident, unless properly coupled up, the automatic accumulators cannot be charged, and unless these are charged there is no force in them to prevent the train starting, and the brakes, by self-application, indicating anything amiss. In order, therefore, to prevent the possibility of the pipes being coupled, and the cocks left unopened, an arrangement has been designed, as stated in the early part of this paper, and, for the reasons there given, the automatic pipes are in duplicate, it mattering not on which side they are coupled up. If injury occurs to any pipe, by coupling up the other side, the train still proceeds on its journey possessed of an efficient brake. The connection is formed by means of a small hose, which is permanently attached to the end of the pipe of one carriage, at its outer end it is provided with special form of coupling. It will be readily seen that, at its outer end or mouth, it has a plug cock, which closes as it is uncoupled. On the end of the pipe, in a corresponding position on the other carriage, is a cock so constructed, that when the hose pipe is fitted close into it, one quarter turn of a lever not

only effects the water-tight coupling (a kind of bayonet joint), but actuates a plug in the cock, and that in the mouth of the hose, and thus opens communication between the two carriages, and so, as the carriages are coupled up, throughout the train. Separate cocks are thus dispensed with, and the risk of their being turned on or off inopportunely is avoided, which, it will be at once evident to all present, is a point of the highest importance, and one upon which the effectiveness of the automatic arrangement entirely depends. The cocks cannot be accidently opened when not required, that is, when the couplings are disconnected, which would let the water out, and put the brake on, as the lever of the cock is provided with a catch, which is released by the act of fitting the hose pipe up to the cock. Inconvenience from this cause is thus prevented.

I employ also a special form of coupling for the direct main water pipe. It has been found most effectual; there is no risk of its becoming uncoupled. The connection is most easily made, and it makes a perfectly tight joint.

In the guards' van a combined hand and hydraulic brake column is used; a nut works loose inside the ram, in which a web or groove is cast, and as the nut works up and down, prevents it turning round. The guard, by turning the handle, screws the nut which forces the ram up. The ram is connected by links to ordinary van brake gear, and, when actuated by hydraulic power, water under pressure is admitted at the bottom, and forces the ram up, thus applying the brake; this plan has been found to work well. Having described the arrangement by means of which hydraulic brakes have been rendered automatic, it remains to be considered—What are the objects to be gained by use of an automatic over a direct or non-automatic brake?

Automatic brakes, whether actuated by air or water, are so arranged, that there is constant pressure in a line of tubes running from one end of the train to the other; should this pressure be destroyed by the pipes giving way, or by the parting of the train, the brakes self-apply themselves, and, so far as I am aware, no system I have seen is self-applying in any other respect. They are sometimes called "Tell-tale Brakes," leading those unacquainted with the subject to imagine if the hose are not perfectly coupled up, or the brake gear out of order, or the brake tackle torn away, they would at once indicate this, and self-apply themselves. This, so far as I am aware, is not strictly so with any system.

First, therefore, what are the objects to be gained by the use of an automatic brake over a non-automatic brake, and the dangers likely to arise from either getting out of order? Shortly, if an automatic brake gets out of order, it generally gives rise to the stoppage of the train, and this feature is regarded as a great source of safety; if a non-automatic gets out of order the brake will not act when required. What are the dangers resulting from such disarrangement in each case? and, in considering this, I shall endeavour to show that there are dangers incidental to the getting out of order of either system, and which, as regards the direct brakes, I am of opinion, have been somewhat over-estimated. In commencing, therefore, with occurrences resulting from automatic brakes being out of order, and the stoppage of trains *in transitu*, I wish it to be clearly understood that I do not desire to depreciate the value of really a good and trustworthy automatic brake, that is, one not liable to become deranged, and cause the stoppage of trains, but I wish to draw attention strongly to the fact that automatic brakes cease to be the great source of additional security to the travelling public if, by their use, they are found constantly to get out of order, and stop, and delay trains, and then, having to disconnect these trains, they are compelled to complete the journey without the aid of a powerful brake of any sort. It is believed, for the reasons given further on, that the liability to such stoppages will be reduced to a minimum in the case of the hydraulic brake; and it will be generally admitted that any system of automatic brakes, through the use of which trains *in transitu* are being continually stopped and delayed, is most undesirable, causing no small amount of confusion to those in charge of the trains, who have neither the knowledge to find out what is amiss, nor the tools or time to put matters right if they do know. In order, therefore, to make automatic brakes desirable, they must be so constructed as not to be liable to frequent disarrangements which, by causing delay as stated, increase the difficulties that already exist and indirectly give rise to danger, which, if incidental to their use, would go a long way to cause grave doubts whether with such systems the increased immunity from one cause of disaster is not more than counterbalanced by the risk incurred from the other sources. Next to be considered are the dangers that the failures of direct brakes give rise to. In the first place it may be broadly stated that no railway company would think of adopting a direct brake that was not reliable. Now, the first objection to them would be, the bursting or breaking of a pipe, causing them to fail when in the act of avoiding a collision; of course this would be a fatal objection. If a direct brake happens to be a reliable one—however, the chances of its failing at such a supreme moment would be very remote. The next liability to failure—and it is with this class of accident that an automatic brake contrasts most favourably with a non-automatic brake — is in the event of the brake-tackle and pipes being torn away through an axle breaking, or any impediment met with on the line; the direct brake in such a case is absolutely useless and valueless to save further disaster. The next liability to disaster is the parting of the train through couplings breaking; of course the direct brake would be of no use in such an emergency. This, however, is not of frequent occurrence, although, *primâ facie*, it would appear that automatic breaks were designed to meet this class of accident.

As regards the liability of direct brakes to fail in approaching junctions and terminal stations, and thus causing disaster, their value in this respect has, I think, been much overrated, inasmuch as drivers always approach such points with their trains well under control; nothing but sheer madness, for which happily our drivers are not distinguished, would cause them to approach such points at high speed. On the North London Railway, which was one of the earliest railways to adopt continuous direct brakes, viz., the chain brake, the chains of which have been repeatedly known to

break, yet there has not been, I believe, a single case of a train coming in contact with the buffer-stop through their failure; and no doubt other cases could be cited showing that though trains may be furnished with continuous direct brakes, still such spots as mentioned, are, nevertheless, approached with caution. In approaching a road-side station, with a clean road through, a driver, to save time, will run in as fast as his brakes will permit him doing. If they fail, the driver runs by, and the train puts back. This is the worst failure that is usually met with in a reliable direct brake, and very little delay and inconvenience results from it, compared with the long delays that are occasioned before automatic brakes can be released and the train proceed on its journey, and the above may, in a great measure, explain, together with the much greater simplicity of direct brakes, why simple non-automatic brakes are in such favour with practical railway engineers; but give them a reliable automatic brake that will not be conspicuous by causing great delays to trains, the advantages connected with automatic action will soon be recognised by them and appreciated. And it must be further borne in mind that, as with automatic brakes the maximum pressure is always on instead of occasionally, all the pipes and hose, &c., are subjected to a much severer test than if the power was only applied occasionally, and everything must be made proportionately strong, so that they may not be liable to give more trouble than the direct brakes.

Having thus compared automatic and non-automatic brakes, and the trouble, inconvenience, and even danger, that may result from either getting out of order, I will endeavour to show that in the use of hydraulic power for actuating brakes, such source of trouble and danger can be more easily guarded against, and thus one of the principal objections of the opponents of automatic brakes be removed. First, it will be evident from the foregoing description, that a small reduction of the normal pressure on the automatic pipes will not apply to the brakes, but a total absence of pressure is required, or very near it, and thus any small leak will not be liable to cause trouble by stopping the train. Secondly, as all fluid brakes depend for their efficiency in being maintained perfectly tight, it will be obvious, when water is employed, how easily any, nay, the smallest leak, may be detected, and how difficult where air is employed.

Another point is, that since dirt of all sorts finds its way into the pipes, there will not be the same liability of derangement with water as where a dry medium like air is employed. Again, it is a well-known fact, that working surfaces at a high pressure with leather, it can, through its swelling, be kept tight with the utmost ease, water acting as its own lubricant, and keeping all the parts in thorough working order. And, lastly, is not water, as stated previously, what any engineer would naturally employ for the purpose, unless there was an insuperable objection to it, making it necessary to use air or other medium. Further on, I will endeavour to show that no such objection exist.

Having pointed out how the efficiency of the brake depends on the pipes being properly coupled through the train, I would draw your attention to the instructions posted up in the guards' vans. According to these directions the rear guard, before departure of the train, signals the driver to apply the brake. Then, by looking at the hydraulic brake column, the guard at once sees whether the brakes on his van are applied. This proves the main water-pipe couplings are properly connected, and by a special arrangement in the van, if the automatic pipes are not coupled up, the main brake will be locked on the train automatically, and the train cannot move until they have been properly connected. The rear guard, therefore, has only to take this simple precaution, and he has an unerring tell-tale, that both main and automatic pipes are properly coupled up, and the apparatus in complete order.

This point will at once recommend itself to all present, with the further view of preventing delays through forgetfulness of those in charge to open cocks, &c.

The arrangement of cock, which has previously been explained, was designed. Lastly, there is a further tell-tale that the automatic rams are all in order. When the automatic pipes are coupled up, the pressure enters each auxilliary accumulator, and from there, through its open port, to the brake cylinders, and thus the brakes remain applied until sufficient hydraulic pressure is exerted to shift the small rams. The train, consequently is unable to move until this is done, which proves at once that the small rams are in working order.

Having now completed the consideration of how far the automatic hydraulic is not only automatic, but a tell-tale brake, and for reasons stated not likely to cause unnecessary stoppage and delay to trains, I will proceed next to consider results to be obtained by the use of the hydraulic power in making quick stops, which perhaps is the most vital point of all, whether hydraulic power is not only powerful, but rapid in its action, and I will endeavour to prove that it must necessarily have the advantage of the greatest rapidity of application. To apply the brake on the direct method, it is necessary to fill the pipes and cylinders and supply enough water to take up the slack of the brake blocks, and, if each time the brakes were applied, the pipes and cylinders, which in a long train would hold a considerable quantity of water, had to be refilled, the work done each time the brake was applied would be very great indeed; however, as the pipes and cylinders are always charged, about two gallons of water only is sufficient to set the brakes. The pipes being one inch diameter, and the pressure 350 pounds to the square inch, it will be evident to anyone here how instantaneous the application must be.

The next point to be considered is the amount of water that has to escape to set the automatic brake. To do this there is a ram under each carriage, two inches diameter, which has to move half an inch; it is loaded with a weight of 400 pounds, and the smallest diameter the water has to pass through to escape is three-eighths of an inch. A calculation, and few minutes' thought, will at once demonstrate that, with a train of twelve carriages, not one second will be occupied in getting the brakes on, therefore, since with hydraulic power only sufficient fluid under pressure is required to take up the slack of

the brake blocks, and with the automatic hydraulic only the amount of water required to escape to set the brakes is the displacement of the small rams, as explained; whereas, with an elastic fluid, the extra duty is involved of charging or permitting to escape the amount of air contained in the pipes and cylinders, the work to be done in this case is necessarily much greater than with water, and consequently, in practice, uncommonly good results ought to be obtained with the latter medium, and the results in daily working fully bear this out. It may be stated, in conclusion, that in the year 1875, a trial was conducted by the locomotive department of the Midland Railway, to ascertain what the brake would do before it was put into regular running, at a speed of fifty miles per hour, the train consisting of ten carriages, was stopped in 200 yards, and this result would be exceeded with the train more recently fitted, and running on the Great Eastern Railway. Trials such as these are important and interesting, as showing, under certain favourable conditions, what are the shortest stops that can be made with different systems. The author believes that locomotive engineers receive such data with considerable caution. The question with them is, what can be accomplished in every-day working with the care and attention of such men as will eventually have to do with them. An engine driver soon discovers what load his engine is equal to, and in the same way a driver soon finds out to what extent a brake can be relied on, and what it will do, and it is such testimony that weighs considerably (and I think with good reason) with practical engineers.

Before leaving the subject of rapid stops with continuous brakes, I would briefly allude to the very interesting experiments that have been recently conducted on the London and Brighton Railway; and the results, so clearly set forth, is an ably written pamphlet by Captain Galton, who has been good enough to take the chair on the present occasion.

The matter has been so thoroughly treated from a practical and theoretical point of view, as to leave scarcely anything to be desired; it has set at rest the much debated question, of whether the greatest retarding power is obtained with skidded or non-skidded wheels, and the very ingenious arrangement of valve for limiting the pressure on the brake blocks, so as to obtain results with skidded or non-skidded, has enabled a series of most interesting experiments to be carried out.

I should gather, however, that this arrangement of reducing the valve was designed more especially for experimental purposes, since the adhesion of the wheels, varying as 2 to 1, so the friction permitted between the brake block and wheel must vary also in the same ratio, and for this there is no provision.

My experience as regards the working of valves, having regard to the dust, grit, and dirt which finds its way into the pipes, would be, that any increased theoretical advantage that such a valve might give would be more than counterbalanced by the disadvantages arising from the introduction of another valve and from leakages, derangements connected therewith, and, for these reasons, likely to impair the efficiency of a brake employing them, than any practical gain to be obtained by their use. The object to be arrived at in the construction of a brake is, that it will work efficiently under the most unfavourable conditions of dust and dirt, which ought to be regarded as the normal state of things. The employment of any valves at all likely to become choked must, in railway working, always be regarded as a serious disadvantage, and a very large per-centage of reduction of efficiency in daily working must be made for any valve so employed. This is my own experience; it is so obvious, that it scarcely requires further observation, and although I have provided no means for limiting the pressure automatically on the brake blocks to prevent skidding, still the regulator gives the driver the power of regulating the force to the greatest nicety, as before explained, and if the brakes are in such a state of efficiency that every wheel throughout a train can in less than two seconds have a force equal to the weight of the train itself, *plus* 25 per cent. of that weight brought effectively to bear upon, and equally distributed on brake blocks, the warmest supporters of continuous brakes will, I am convinced, be perfectly satisfied with the stop effected. It is the difficulty in daily working of having the brakes in such a high state of efficiency.

I would now proceed to draw attention to the fact that brakes are required for two purposes, hence the great value of being able to regulate the power in the perfect manner for which the hydraulic brake is distinguished. One class of stop is for security, so that, on an emergency, a train can be stopped in the shortest distance, the other for traffic convenience, viz., to enable time to be saved in stopping at stations. There is further a negative advantage attendant on their use; they not only save time in stopping at stations, but in furnishing trains with an effective means of stopping, it enables them to run between signals in bad slippery weather at the same speed as in dry weather; the confusion which arises from delays at such seasons is thus avoided, and the source of danger arising from unpunctuality of trains got rid of. The author is aware, with the block system of signalling, unpunctuality or stoppage of the trains through brakes being out of order ought not to be an element of danger. Still, few railway men but would admit that unpunctuality gives rise, in certain cases, to some confusion and risk. Even when used for emergency, the brake power is required to be of such a character as to bring the greatest retarding force to bear in the shortest time, and, for certain classes of accident, the power to commence from the rear of the train; if this is not practicable, the next best thing is, that the brakes should be applied as simultaneously as possible, so as not to telescope the train. When used for the second class of stopping, the power can be applied with the best advantage by using it gradually, with little power at first; this should be by degrees increased or diminished, as is found necessary, to pull the train up at the spot required, taking care just to release the brake before it has come to a dead stop. In this way the passengers are unaware that there is a brake on the train; by releasing the brake at the last moment, no jerk is experienced on the train coming to a stand.

and by applying increased power as the train moves slowly, time is saved, for it is when the momentum is destroyed, and train speed reduced to ten and five miles an hour, that the time is lost, and seconds rapidly count up. Brakes applied thus must also cause considerably less strain on the brake tackle and rolling stock. It will be thus seen that there are two distinct classes of stops to be provided for. In order also always to have in practice the maximum brake force at command for emergencies, the force in the main reservoirs should not be capable of variation when in use; the maximum force should be there, independent of any attention on the part of drivers, otherwise it will be apparent in a case of emergency that the pressure in the accumulators may, by carelessness, be allowed to be considerably under what it should be, and the efficiency of the brake proportionately impaired, and even disaster result therefrom. It will have been evident from the foregoing description of the brake, that by means of the regulator described for ordinarily stopping, the driver can increase or diminish the pressure at will, and, in case of danger, by pulling the handle over hard, he at once applies the force of water in the accumulator, which, from its construction, is always a little over double the pressure in the boiler, and if the brake is at work, he always has this maximum pressure at instant command, independent of any attention on the part of the driver; and thus any carelessness or oversight on his part, at a supreme moment of danger, is not likely to deprive him of the full power the brake is capable of exerting. The next point has been already alluded to, and it is one to which I believe the Board of Trade rightly attach considerable importance. It is the provision necessary to meet the case of a train leaving the metals, and to prevent any chance of the use of brakes aggravating, and being the cause of a disaster, instead of mitigating it. It is well-known that many cases have arisen, when carriages have left the metals, and the driver has had the presence of mind to bring his train gradually to a standstill, the train has run a considerable distance in this state, and eventually been brought to a standstill without any serious disaster resulting; the case, however, would probably have been entirely different, if the driver had suddenly reversed his engine and applied his tender brake, causing the carriages to telescope. It may be broadly stated that with all continuous brakes, actuated from the engines, the power commences from the engines, and it takes different degrees of time, measured in seconds and parts of a second, to reach the further extremity of the train; in some systems, the time that elapses is longer than in others. This must generally be admitted to be a defect, and as I stated previously, if the power exerted cannot commence from the rear, it ought to be simultaneous, and this I will endeavour to show the hydraulic direct brake practically to be. In order to demonstrate this conclusively, it would be necessary to fit each carriage with a pressure gauge, and an electrical means of obtaining the precise time the needle pointed to the maximum pressure, but as this paper is addressed to a scientific body, it will be generally conceded that, owing to the incompressibility of water, whatever pressure is at one part of the train, it must be the same everywhere else at the same time; and on account of water being non-elastic, this simultaneous action will be obtained much more perfectly with water than can be the case with an elastic medium; results in practice fully bear this out. It must be borne in mind that simultaneous action must not be judged from the time the blocks touch the wheels, but from the instant effective hydraulic pressure is brought to bear on the brake blocks, and this, I consider, will be found to take place at the end of the train at the same moment as on the first carriage; practical experience confirms this, since however rapidly the hydraulic brake is applied, the couplings remain in tension the same as when the engine has steam on. The next point I will bring forward is the popular objections that have been made to the use of hydraulic brakes. First, it may be generally stated that the principal argument employed against them has been that they would be useless in the winter. What has been the experience of seven winters? Why, not a single instance has arisen in which the use of common salt to prevent freezing has not been perfectly effectual. Not only so, on reference to last half-year's Board of Trade Brake Returns, an extraordinary unlooked for fact appears, viz., that nearly every system of continuous brakes in extensive use has been affected by the frost except the hydraulic; in the case of the hydraulic not a single failure from this cause has occurred. Another objection has been that a tank has to be provided; 60 gallons of water only have to be carried, the same water being used over and over again. What practical objection, therefore, can there be to this. There is, however, this advantage attached to it, it at once furnishes the driver with an unerring guide as to the tightness of the pipes and fittings of the train, any loss of water the driver will be at once made aware of, and it is quite certain that he will not cease reporting such leakage until it is put right, from the simple fact that he will have the additional duty of repeatedly filling the brake tank.

Another objection has been made, but how this impression has got abroad it is exceedingly difficult to understand, but as I have seen it once or twice publicly stated in the papers, it may be as well to repeat it here, viz., that the hydraulic brakes are rough in their action, when, of all the brakes in use, there cannot be found one that is so conspicuous for being an easy riding brake. Any engineer or passenger who has been in the habit of riding in the trains fitted with hydraulic brake can vouch for the truth of the following statement. I unhesitatingly assert that it is the most easy riding brake of any in existence. The last objection has been cost. It might be interesting to the meeting to have some authentic details on this subject, but as I have only had the opportunity of fitting up experimental trains on the Midland and Great Eastern Railways, both different, the brake on the Midland line being the first train fitted with the hydraulic brake worked from the engine, and on the Great Eastern line, the first on the hydraulic automatic principle, I will not commit myself to figures, but the prices that these trains have cost enable me to state that I should be prepared to fit up trains at a less cost than any other system

giving similar results. At some future day I shall be happy to give the Society the exact figures at which the material can be supplied and fitted to the carriages; the cost will be very small, compared with what those unacquainted with the system might expect, but at present it would not be fair to the system, or to myself, to go minutely into this matter. I do not suppose that the fitting of the tackle to the stock, both on the Midland and Great Eastern lines, was otherwise but costly; but the sums expended were not that actually employed in attaching the material to the carriages and engines, but for alterations, by way of experiment, and modifications and improvements which experience showed to be desirable, and which the companies were good enough to sanction my carrying out to perfect his plans; these have resulted in the arrangement just described.

Lastly, as regards the effect of water on the materials employed; the paper has already reached a considerable length, and I will state, therefore, briefly, that water and leather are known to be on the best of terms, and that india-rubber stands the action of water better than anything else, the metallic parts of the machinery not being exposed to the atmosphere, the oxidising effects that would otherwise be injurious are not sensibly felt, even where salt and water are employed, which I feared, at one time, would be found more destructive than it has proved to be.

DISCUSSION.

The Chairman said he should like to ask Mr. Barker whether he could alter the pressure of his safety valves during the progress of a stop, and also what the amount of water was which was required to bring the brake blocks on.

Mr. Barker said the pressure could be increased or diminished during the progress of a stop, and about two gallons of water were required for a train of twelve carriages.

The Chairman said he understood that brakes were applied throughout the train simultaneously, but if two gallons of water had to be supplied to the pipes before the action took place, the power could not be applied simultaneously.

Mr. Barker said the pressure was applied the moment the two gallons got into the pipes.

Mr. Hale thought it would have been as well if the paper had given the time of stoppage as well as the distance, because it was a very material point. He had read with pleasure the Chairman's account of his experiments on the Brighton line; but could not quite follow him in the conclusions that it was preferable not to skid the wheels.

Mr Seeley said he might mention a curious fact which occurred to him some years ago, as bearing upon the question of skidding the wheels. When quite young, his brother and himself were out on a double velocipede for a considerable journey, and they went on to a frozen pond. They attempted to stop when nearly at the end of the pond by a sudden stoppage of the levers, but they then found that the velocipede became like a sledge, and went on to almost any distance, but if they slackened so as to move the wheels slowly, they stopped in a much shorter distance, *i.e.*, they had much greater power to stop them if they continued moving than if they made a sudden block, and allowed them to run like a train did. A remark had been made in the paper about an accident occurring in one carriage and breaking the pipes. It struck him that that might be avoided by a stop-cock, and allowing the carriage to be discontinued from the rest, so that the brake would act in all the others, but would be disconnected.

Mr. Haughton said, although not competent to speak on this matter as a professional man, he should be glad to have a little further information on a point suggested to his mind by the Chairman's observations, namely, the time of the application of the brake to the wheels of the different carriages. They might take it as a fact in physics, that a column of water enclosed in a pipe or tube, and compressed by pistons at either end, would act practically as a rigid bar, and, therefore, any force applied at one end would be communicated to the other end; but yet, if he followed the paper correctly, that was not precisely the state of things which existed in this brake; but that before the force could be brought to bear on the further end of the train, it was necessary that two gallons of water should be supplied through a small orifice. This appeared to be a different state of things to what he had supposed. It was not a full tube with a stopper at each end, or a movable piston at each end, but a tube which partly full had to be filled, and they were all aware that the frictional resistance of fluids in tubes was very great, and that taking that into account, considering that the vacant part might be at the end of the train, it was quite possible that the force might be applied to the wheels of trains close to the engine, before applied to those at the rear. Next to certainty, rapidity, and efficiency, in putting on a brake, it was of importance that it should be applied rather to the rear than the front.

The Chairman said there were very few subjects at the present time connected with railway travelling which had the importance this had. A question had been raised as to skidding, and the reason why it was less efficient than braking a wheel and allowing the rotation still to go on. The fact was derived from the experiments which he had made with the assistance of Mr. Westinghouse on the Brighton line, showing that the friction between surfaces moving at a very high velocity was much less with the same pressure than that produced when the surfaces were moving at a slow velocity, just passing the stationary point. If you considered the rotation of a wheel, the part of the wheel in contact with the rail at the moment at which it is practically stationary—for the rotation gives the tire of the wheels at that part a backward movement which counteracts the forward motion of the train, and makes that point at the moment it is in contact with the rail stationary—you have then, therefore, the friction corresponding to the stationary condition or static friction, whereas, when the wheel was skidded, and it slid along the rail, you then had friction corresponding to the friction of movement, which was considerably less than static friction. That quite accounted for the difference between the effect of a wheel braked and rotating, and a wheel skidded and sliding on the rail. In considering this question of continuous brakes, no doubt the important point to attend to was to apply such an amount of friction to the wheels as would retard the wheels just short of the skidding point, and to apply that with the greatest rapidity possible. In starting a train the engine attained its force for drawing the train, by means of the adhesion of the wheel on the rail, and the brake was exactly the opposite; it retarded the train equally by means of adhesion; and in order to retard it with sufficient rapidity in the case of accidents, you should apply that retarding force to every wheel of the train, by which means you were able to stop each carriage in the smallest possible period of time. The adhesion between the wheel and the rail, which was a function of the weight of those wheels, was the limit of the force which you could apply for stopping the train; and there was no doubt that if you could so regulate the friction as to

make it at each moment of time to be just short of the adhesion of the wheel on the rail, you would get the best result. Now, the friction varied with the velocity; when you had a very high velocity, you required a very great pressure to obtain a friction equal to the adhesion, whereas, when the train was coming to a standstill, the same amount of friction would be obtained with a much smaller degree of pressure. The Westinghouse valve, which was alluded to in the paper, was invented for the purpose of diminishing the pressure as the speed decreased, and thus keeping the friction uniform. Of course, until anything on railways had been in actual practice, no one could give a confident opinion as to whether it would be permanently adopted or not, but there was no doubt that in the trials which were made with it the effects of the valve were very marked indeed. On the Brighton Railway they had a stop in 171 yards at 60 miles an hour, equal to a stop in 118 yards at 50 miles an hour, the time being about 12 seconds. That was on a rise of 1 in 264. On the level there was a stop in 148 yards as reduced to 60 miles an hour. On the Paris Lyons, and Mediterranean Railway, the stop was made, with a train, of which all the wheels were not braked, and it was estimated that if they had been, the stop would have been made in 128 yards at 50 miles an hour. He could not say at this moment what the time was. One important point which these experiments brought out very fully was the necessity of the simultaneous application of the brakes to all the wheels of the train. Mr. Barker said his brakes were applied simultaneously; and he should very much like to test that in the same delicate manner in which the other experiments were made with the vacuum and the Westinghouse brakes. In the former the time at which the brakes came on the last carriages was considerably larger than in the Westinghouse, but in neither was it simultaneous. In the Westinghouse it took about $2\frac{1}{2}$ seconds to reach the end of a train of 14 or 15 carriages, and with the vacuum, considerably more. The effect which is produced by the brake being applied very rapidly close to the engine, and taking a notable number of seconds to come on at the further end, is that the carriages at the end run into the front carriages, and causes the buffers to be compressed; then when the brakes come on applied at the rear end, their action, combined with the recoil of the buffer springs, very frequently causes the train to break in two. It was quite evident, he thought, that in Mr. Barker's brake, even if it be the case as stated, that if the pressure was applied simultaneously to everywhere in the train, there would be a certain loss of time before you began to apply the brake, while you were filling the pipes with water.

Mr. Barker said the pipes were already full; it was to take up the slack of the brake blocks.

The Chairman said he had a strong opinion that the automatic brake was very desirable, and that if the brake failed to act, it should be notified in some very distinct manner to the driver or guard that it was out of order; also that if a train broke in two, the brake should be applied so that each part should have the power of retaining its brakes on after it was detached.

Mr. Hale asked if that was the case with the Westinghouse brake?

Mr. Westinghouse said that if the train broke in two, the brakes went on and kept on until the pressure leaked away, which might be from two to 24 hours.

The Chairman said everyone would be agreed that the brake question was one of the highest importance at the present moment to the public, and the travelling public, he believed, would be of opinion that the automatic brake was a very great desideratum. He knew there were some railway men who rather opposed the introduction of the automatic brake, but he did not believe that the public would be satisfied unless something of the sort were adopted.

Mr. A. G. Harris wished to ask the Chairman a question with regard to his interesting experiments. He had attained results which were theoretically perfect, and showed the difference between the static friction of the brake when there was no stationary point whatever; but he wanted to know whether that result would not be different according to circumstances. As he understood, the experiments on the Brighton line were conducted in this way: A car was fitted up, a single pair of wheels of which only were skidded, the other pair being quite free, and they either skidded that pair or allowed them to revolve, putting on as much pressure as they could without actually skidding the wheels. He wanted to know whether, if you skidded the whole of the wheels, it would not so alter the case; whether it would not really be safer, theoretically and practically, to put on all the power at command in the case of an emergency, and skid every wheel, as you would then know what pressure you had on, and this, at very high velocity, was something enormous, equal to nearly 50 per cent. above the entire weight of the carriages. He should also like to know whether, in the experiments on the Paris and Lyons Railway, the new leakage valve was applied to each cylinder under each carriage, so as to give different results to those obtained on the Brighton line; and, if so, whether accurate observations were taken in different places of what stop they could make by suddenly skidding all the wheels, or by using leakage valves, so as to get the highest pressures just short of skidding them.

The Chairman did not think that skidding the wheels would alter the surface of the rails at all so as to increase the resistance. The fact was that the effect of the continued application of the brake blocks to the wheels was to reduce the friction, that is to say, in the first two or three seconds they were applied, you had more friction than you had after five or ten seconds, the pressure remaining constant; the friction diminished in a certain ratio with the time during which the pressure was applied when at high velocities. Therefore, he should imagine, you wouldnot improve your chance of stopping the train by skidding all the wheels; but, if anything, the result would probably be less favourable. In the experiments on the Paris, Lyons, and Mediterranean line, there were friction valves attached to each set of wheels; the whole of the wheels of the train were not braked, but only a proportion of each carriage. In some of the experiments on the Brighton Railway, they had all the wheels of the experimental van braked, in others only one pair of wheels braked.

Mr. Seeley said an engineer always turned off his steam when he found the wheels slipping, and then when they came to rest, turned it on again.

Mr. Houghton asked what was the distance of the brake blocks from the wheels.

Mr. Barker said a quarter of an inch to each block, so that the ram would have to move half an inch. The cheif question seemed to be whether the pipes were full of water, and this he could easily explain. The pipes were always full of water, and the amount you had to force in was simply that necessary to bring the blocks in contact with the wheels. In a train of 12 carriages, making ample allowance for everything, two gallons would be required, and two gallons would issue from a hole one inch in diameter, at a pressure of 350 lbs., in less than a quarter of a second. Of course, you had to make allowance for friction in the pipes, but, making every possible allowance, he did not think it would take one and a-half seconds in a train of 12 carriages; that was the theory, and, practically, he had no reason to suppose it took longer. The time required to apply the brakes was, therefore, one and a-half or two seconds at the outside. In the case of the automatic valves, they scarcely required a pint of water to escape, which at a pressure of 100 lbs. through a three-

eighth of an inch hole would be still more instantaneous. Almost all brakes had an arrangement for cutting off one carriage if it got out of order. With regard to the question of skidding the wheels, the results varied so constantly in different states of the weather, that experiments conducted one day would almost negative the results obtained the day before in a different state of the rails; but there was one point alluded to in his paper which had not been touched. You might devise a valve which would limit the friction so as not to skid the wheel, if the adhesion between the wheel and the rail was always the same, but as this adhesion varied considerably in greasy and dry weather, it would not be possible. If you arranged the valve so that the wheels would not skid in dry weather, they would pick up directly with a greasy rail, and if you limited the pressure so that they would not skid with a greasy rail, you would not have anything like the power you might have for a dry rail. As regarded skidding the wheels of a whole train or just allowing them to revolve, it might be a question whether the adhesion of the wheels throughout the whole train on being pulled up, and the dust created thereby, would not cause a different condition of the whole train to what was produced when only one van had the wheels skidded. That was entirely a matter for experiment. For general purposes he thought if 25 per cent. over the weight of the train could be efficiently applied to every wheel throughout the train, it would make a remarkably quick stop. The Chairman agreed with him on the importance of simultaneous action, but in order to settle that question definitely, very delicate experiments would be necessary. He contended that his action must be more simultaneous than any other, because water being non-elastic, he did not see how it was possible to get much pressure at one part before you got it at another. If you used an elastic fluid, the friction of the fluid through the pipes might perhaps make a considerable difference, and that was clearly shown in the case of the vacuum brake. He believed practice would thoroughly confirm theory on this point.

The Chairman then proposed a vote of thanks to Mr. Barker, which was carried unanimously, and the meeting adjourned.

MISCELLANEOUS.

RECENT EXPLORATIONS IN FRENCH GUIANA.

In his lately published report on the trade, &c., of French Guiana in 1877, her Majesty's Consul at Cayenne gives some interesting particulars respecting the country, and an expedition across its interior to the Amazon, recently brought to a successful termination by Dr. Jules Crevaux, a French naval doctor. The expedition originally consisted of M. Crevaux, two priests, and twenty men. The priests fell dangerously ill after a month's travelling, and returned to Cayenne. The men also abandoned the Doctor; but he persevered, ascended the Maroni River to the foot of the Tumac Humac Mountains, crossed them, and, finally descending the Yary River, reached the Amazon, after a march of 142 days. In the course of his journey, he travelled over 500 leagues of land and water, 225 of which were through an entirely unexplored region. Although the results of this journey with regard to the nature of the country, the flora and fauna, the mineral and vegetable riches, the manners and customs of the red men inhabiting the Tumac Humac range cannot, from the rapidity with which it was made, be very important, yet one cannot but admire the energy and perseverance of Dr. Crevaux—after the loss of his companions and the defection of his men—in continuing the journey with only one negro and a Boni savage picked up *en route*. The two principal results of his journey he states to be:—(1) His having succeeded in crossing the range, which numerous explorers had failed even to approach during the last three centuries; and (2) his having discovered the true delineation of an important effluent of the Amazon, the River Yary, the navigation of which is of the most perilous kind.

The Boni and Roucouyenne Indians, although not antagonistic to the traveller, gave him no material help. The chief of the Bonis, indeed, caused him a delay of a month among them by refusing him guides, under the pretext that the whole of the tribe were required to attend the obsequies of a chief. The Roucouyenne Indians, again, deserted him at the most critical moment of the journey, on their arrival at the grand falls on the Yary River.

From observations made by Dr. Crevaux it would appear that the altitude of the Tumac Humac chain is not so great as is generally believed, it being only, in fact, about 1,300 feet above the level of the sea. He points out also the remarkable difference in the altitude of the valley through which the Maroni flows from the chain to the north, and of that through which the Yary winds to the south.

In speaking of the numerous routes across the chain available for communication between French Guiana and the Amazon, M. Crevaux states that there is one of particular interest—namely, that by the Yratapùru, which has no rapids to speak of, and falls into the Yary below its grand and most precipitous cataracts; and that, by that route, the traveller could accomplish the journey from Cayenne to the Amazon in 45 days.

It appears, Consul Wooldridge remarks, that the tribes of Negroes and Indians dwelling in the valley of the Maroni find it to be to their advantage to deal with Dutch Guiana rather than with French Guiana, and carry to Surinam quantities of valuable wood and other rich vegetable productions instead of to Cayenne, in consequence of greater facilities of communication, for a branch of the Maroni River flows into the Surinam River, and thus the town of Paramaribo is easily reached by canoes, whereas, to get to Cayenne, it would be necessary to go to sea, and coast along the shore for more than 200 kilomètres. The Roucouyennes and the Youcas are constantly at war with the Boni negroes on the west bank of the Awa River, the chief affluent of the Maroni; and an enterprising Frenchman, named Labourdette, who has established a "placer" on this river, on account of one refusal of the Bonis to allow the Youcas to pass with provisions for him and his labourers, narrowly escaped starvation. M. Labourdette's placer is situated 163 miles from the mouth of the Maroni. M. Crevaux is of opinion—and he is supported by M. Labourdette in his view—that the range of Tumac Humac is not the only source of the gold production of French Guiana, but that the lower chain running through the colony contains most of the gold which is found in and along the *criques*. He found quantities of coal in many places, both in the valleys and in the hills. The Tumac Humac range, no doubt, abounds with the precious metal, which may be found in considerable quantities in the rivulets flowing through a plain into the Itany River, an affluent of the Awa; the soil of this plain is formed of earth and rocks, which, through ages of time, have been swept down from the mountains, and which contain the gold. It requires thirty-three marching days of eight hours each to reach the foot of the Tumac Humac range from the mouth of the Maroni, and for fifteen days, so sparse is the population of Indians along the river, there is no opportunity of obtaining provisions, and in no case, even when met with, are the natives to be depended on for revictualling. To

obtain cassava and bananas the traveller has to continue his journey without stopping till he reaches the first village of the Roucouyennes, where he may be relieved. In his description of the wonderful sights which met his eyes in the *grand bois* of French Guiana through which he passed, M. Crevaux mentions having seen immense trees springing up like columns, forty-yards in height, and bearing a crop of verdure in many parts impenetrable by the sun's rays.

It may be of interest to add that the French Geographical Society have recently published in their *Bulletin* Dr. Crevaux's detailed report of his journey, which is briefly described above, together with two maps, giving much new geographical information.

Since the foregoing was written, news has been received that Dr. Crevaux has successfully accomplished another journey across the Tumac Humac range, which on this occasion he reached by a different route, viz., that of the Oyapock River.—*Colonies and India.*

ORANGE FLOWERS AND ORANGES FROM THE SOUTHERN STATES.*

By W. B. Rush.

In Florida, the orange, lemon, and lime grow wild, and are found in abundance. In Louisiana and Mississippi, they are grown from the seed. The seeds are planted in early spring, or in hot-beds in January. When one year old, they are transplanted in a nursery arrangement. At the age of two and a half years, they are budded, *i.e.*, the seedlings are of the sour variety, and, to produce sweet oranges, fully matured buds are taken from bearing trees and inserted. This is done to render the tree more hardy, since the sweet seedlings are subject to a root disease called heel, while the sour seedlings are not. Hence, orange-growers resort to this means to produce sweet oranges. The trees are transplanted, at the age of four years, into orchards. At the age of six, flowers first appear, and at ten years the trees are called full bearers.

This beautiful evergreen is found in every civilised country where the climate is favourable, and in colder countries it is the cherished ornament of the hot-house. It flourishes in the most southern limits of the United States, largely in Florida, and to a considerable extent in Mississippi and Louisiana, south of the lakes. In Mississippi and Louisiana they are favoured by the lakes tempering the cold north winds. There seems but little difference between these States in their favourable localities. However, the tree requires delicate cultivation and studied treatment. About the year 1816, oranges were introduced, as ornaments, to the States, by the French. In 1830 an orange tree in a box, in bloom, brought 400 francs, and about this time some attention was paid by horticulturists, and blooming trees in boxes were sold at from 50 to 100 francs in New Orleans. The beginning of the cultivation of oranges for fruit, in the South, dates back to 1848, when numbers of trees were planted, but in January, 1856, a cold wave from Texas brought the temperature down to 10° F. above zero, and a large proportion of the trees were killed. Not much attention was paid to the cultivation afterwards until 1867 and 1868, and since then orange growing has been quite successful, and assumed commercial importance.

The time of flowering is from the beginning of February until the 10th of April, in healthy trees; unhealthy ones are found in bloom sooner or later. The last week of February finds most of the trees blooming. The petals remain on the flowers for about two weeks. Unfavourable conditions, shorten the time. The humidity of the atmosphere materially affects the flowers—when too wet the pollen heads are injured and the secretions are imperfect. Dryness has a similar effect on the pollen and nectar, but does not affect the secretion of oil. When the temperature is too low, but few flowers are fructified, the oil cells are limpid and no nectar is secreted. The most favourable temperature is about 68° to 76° F. Under 60° F. flowers are blighted. When the busy bee is found collecting the nectar, the conditions are favourable for the development of flowers and fruit, and then the flowers contain their most agreeable odour.

An ordinary tree will yield from two to ten pounds of flowers, ordinarily about seven. As soon as the petals begin to fall a canvas is spread under the tree, and by brisk shaking the petals will fall, with some leaves, which are easily separated. The time when flowers are most fragrant is early in the morning, and late in the day the odour is greatly diminished. Prior to the late conflict, negroes collected and sold orange petals in New Orleans. A tea-saucer full (about 2 ozs.) was measured out, put upon a china plate and set in the room, for which the negro received about 50 cents. From two to three plates would perfume a room for a week. Orange flowers produced in the extreme southern borders are believed to possess a stronger odour and more oil. The difference is accounted for in this manner:—In the tropics and semi-tropics, the trees do not begin to bear very much until about 20 years old, while in this country they begin at about seven. The development is more rapid, the tree more vigorous, and it is reasonable to suppose a better development of odour in the flower. The writer was informed by an orange-grower who had made extensive observations in different countries, and fully confirmed this supposition. The flowers are more fragrant, and the fruit more juicy, but not so sweet as in some other countries.

The United States pharmacist buys the products of the orange from over the sea. That name "imported" always adds an imaginary value of more than 100 per cent. It is said to pay the producer of California wines to send his wine to France, and, having the label changed and translated into French, bring it back here, pay freights and double duty, and then realise 100 per cent. on the transfers, because the consumer considers it far superior to our wine. Just so with our neroli, and the orange flower water, and fruit juices. Almost all the crude material for citric acid is imported. This need not be. There is abundance to be had in the South. Florida furnishes flowers sufficient for America for the oil of neroli, orange flower water, citric acid, fruit juice and oils of the rind, and if no misfortune happens to the sweet orange plantations, there will soon be fruit sufficient for the United States from the 1st of November until May.

The writer made several experiments with orange flowers. When placed in direct sunlight, in the course of two days they lose all their odour. In diffused daylight they retain it for at least three days, and in a dark humid atmosphere the odour is quite distinct after one week. When bruised, they lose their odour in half of the time stated. The writer had no means for experimenting as to the amount of volatile oil, but he believes that the better plan for the pharmacist is to have the petals hermetically sealed and to make his preparations direct.

Orange-flower water is one of the most agreeable vehicles for nauseous medicines that we have, and when the pharmacist can make fresh preparations, they will be fully appreciated and the expense will not be greater. The syrup of either flower or fruit has no superior, especially the syrup of the fruit. A honey collected from orange flowers is very fragrant with the orange odour. The flowers, placed in tin cans and sealed up, are known to have retained their ordour unimpaired for nine months. As a perfume they have no equal. To sit under a tree when in full bloom is delightful, the fragrance intoxicating. If any one has made the syrup of orange from the fresh juice of the fruit and used it, he will not want to use any more which is made from simple syrup and a few drops of the oil of the rind.

* From a paper read at a meeting of the Philadelphia College of Pharmacy, January 21, 1879.

ELEMENTARY MUSIC IN TRAINING COLLEGES.

Date of Education Reports.	No. of Students Examined.	Per-centage of Students passing.	Remarks abstracted from Mr. Hullah's reports in the Annual Reports of the Education Department, published for Parliament.
1872-73	About 1,500	58·74 female 60·96 male	Organisation of training colleges generally unfavourable to choral music. Time devoted to music generally insufficient. Papers by acting teachers in most instances very bad.
1873-74	,, 1,620	74·55 female 78·05 male	Suggestions generally adopted in regard to improvements for teaching music.
1874-75	,, 1,828	No per-centage given in report	Still a want of system in musical instruction. No instruction given to pupil teachers who enter training colleges. Urges necessity of inspection in elementary schools, and notices the words "satisfactorily taught" singing in New Code in *re* elementary schools.
1875-76	,, 1,807	No per-centage given in report	Progress has been made. Per-centages are an imperfect expression of relative skill.
1876-77	,, 1,964	No per-centage given in report	Generally favourable reports as to training colleges. Remarks strongly on imperfections of elementary schools system.
1877-78	,, 1,959	No per-centage given in report	During the course of six years the condition of music under authorised musical instruction is not altogether unsatisfactory. Again reverts to imperfections in elementary schools—the want of inspection—the waste of money paid for children returned as taught.

RESOURCES OF NORTH ALBANIA.

Vice-Consul Blakeney states that the political convulsions in these provinces, are expected to bring to the surface futures of development and prosperity, such as are warranted by their natural resources and geographical positions. Setting aside the accidents which may retard or divert this hopeful advancement, there are advantages, in a latent state, possessed by the province of Scutari.

There can hardly be a doubt that, ere many years are over, the network of railways in European Turkey will have extended its meshes from Constantinople to Salonica, and that these lines will have joined those of Austria, *via* Nisch and Widdin, and *via* the Herzegovina and Bosnia. Salonica will then immediately enter into competition with Brindisi as an overland Indian route, and become an artery for the mercantile circulation of the Levant. One disadvantage, however, it will have to contend against. The rigorous winters of Eastern Europe will always tend to check traffic for a third of the year. A branch line to Monastir, Ochrida, Tirasma, and so on to Alessio and San Giovanni di Medua, would at once overcome the climatic failing, and if it does not absorb, owing to the necessary passage across the Adriatic, the carriage of the merchandise bound for the western European markets, leaving to its rivals only the custom of the central Europe, nearly the whole of the passengers would most certainly turn away from the icy Danube and the freezing blasts of the Roumanian and Hungarian steepes.

The foregoing prospect of North Albania becoming a piece of one of the principal high-roads of the world, however, would barely suffice, when realised, to lift it from its present poverty. Development, in a more local sense, is necessary to effect this, and a demand for its agricultural and farm-yard produce created through increased facilities of communication with the neighbouring countries would give the required impetus. The River Boyana might easily be made, and at a comparatively small cost, to supplement the total want of a good road from the sea coast to Scutari, and also become a securer haven for stopping than the exposed roadsteads of Antivari and Durazzo. At present, only vessels of a very small tonnage are able to reach the anchorage at Oboti, a village on the river ten miles from Scutari, owing to a bar at the Boyana's mouth. One or two powerful steam dredges would probably easily remove the bar and the banks, and the expense of their working could be covered by fair shipping dues. The Boyana once opened it would only be necessary for some enterprising company to facilitate commerce by establishing rapid and easy communications with the opposite coast of Italy.

North Albania is very well clothed with forests of valuable timber of oak, pine, beech, &c., and the dread of the Turkish Government to make a bad bargain with foreign capitalists, who were always offering to purchase the forests, has luckily preserved them more or less intact. Had the offers been accepted, it is probable that the land would have been speedily cleared of every scrap of wood, as the purchasers would only have been animated by a sentiment of immediate profit, and with no care for the country's welfare. Now, with a prospect of better administration, both forests and mines may shortly be worked to the advantage of both stranger and natives.

PLANTING OF THE EUCALYPTUS.

Consul-General Playfair mentions that his report upon the growth of the eucalyptus in Algeria* has attracted numerous letters of inquiry respecting the best means of raising and planting these trees, and he thinks it may be of use to record, as the result of repeated experiments and failures, the best *modus operandi*. Extremes of cold or heat, he observes, are both fatal to success. The eucalyptus will stand a slight amount of frost if not of long continuance, and a considerable amount of drought if well rooted, but it is as hopeless to attempt to grow it within the tropics as it would be in the North of Scotland.

The eucalyptus will succeed best in places where there are only two marked seasons—the cool and rainy one lasting from October to April, and the hot and dry one

* This appeared in the Society's *Journal*, Sept. 21, 1877.

from May to September. In such places water will naturally be scarce, and it may be assumed that either on this account or owing to the expense of the process, artificial irrigation will not be attempted if the plants are to be grown on a large scale. The first sowing of the seed should take place in the beginning of May, so that the trees may be ready to be planted out the moment that the first rains of autumn render the ground sufficiently moist. The preparation of the land, however, should take place at an earlier period.

Where a considerable surface is to be planted, the land should be ploughed in spring as deeply as possible, furrows should then be driven at four mètres apart with a subsoil plough, so as to attain a depth of not less than 50 centimètres, but 75 if possible. In this condition the ground may be allowed to remain all summer. About the beginning of May commence sowing as follows:— Prepare a compost of vegetable mould and river sand, very finely sifted. Fill the pots of 15 centimètres in diameter, press the earth lightly and evenly with a small zinc cylinder, of about the same diameter as the pot. On this surface scatter the seed so as nearly to cover the whole of it, then with a very fine sieve, which may be a zinc cylinder similar to the other, but perforated with very minute holes, sift just enough of the compost on the seeds to cover them and no more. Press this surface again lightly with the first cylinder, and water with a watering-pot, the rose of which is perforated with the smallest holes which it is possible to make. Within fifteen days the seeds will have germinated; in about six weeks the plants will be ready to pot out. As soon as they have made about four leaves, transfer them to pots of 10 centimètres in diameter. Keep them in a shady place for the first day or two, and then transfer them to a sunny position. Keep watering during the summer just sufficient to prevent them dying. The great object is to retard their growth during summer, so as to keep them small and prevent their roots penetrating through the drainage hole of the pot into the ground, or becoming matted inside the pot itself. It will be better to place them on a terrace of concrete than on the bare soil, or ashes may be used instead. This serves not only to confine the roots to the pot, but it prevents the ravages of earth worms, which are very fatal to the young plants.

As soon as the ground, which has been prepared in spring, is saturated with the rains of autumn, plant out the young trees at intervals of four mètres in the trenches, and as they increase in height, fill up the trenches, till in six months they have entirely disappeared, and instead of a depression the earth becomes filled up round the stem of the young tree; this serves not only to keep the roots moist, but to prevent the slender stem from being blown over by heavy winds. It is well to give each plant a good watering when put into the ground, but they will never require another. The soil should be kept free from weeds and open for the first two or three years, which may conveniently be done by passing a cultivator between them in each direction once or twice a year. After the third year they may be left to themselves and will require no further care. Four mètres apart has been stated as the best distance for planting, but at the end of ten years every alternate plant in the row, and every alternate row in its entirety, may be cut down, leaving the remaining trees at eight mètres apart.

If eucalyptus is to be planted on a small scale, instead of trenches, holes 50 centimetres cube may be made; but this is not to be recommended in the open field, as the heavy rains are apt to fill up the holes with earth and smother the plant, instead of being carried off by the open trenches. A second sowing of seed may take place about the middle of September, so as to obtain young plants ready to put into the ground about the beginning of spring. In some respects this plan is preferable to the other, and it is always so when the plants can be watered in summer. The young trees have a shorter time to remain in the pot, and their roots run less chance of becoming matted; but often, when the rains cease early in the year, they have not become sufficiently rooted in the ground to enable them to resist the heat of summer without occasional irrigation.

The eucalyptus is a plant that does not stand being long kept in a pot: its roots grow with as great rapidity as the rest of the tree, and if they are allowed to be contorted round the inside of the pot, the tree never recovers from this unnatural condition of things, and seldom grows straight and healthy. The proper moment to plant out is when the roots have forced themselves through the earth in which they are planted, and have just reached the inner circumference of the pot without having had time to make any convolutions. All the experience hitherto gained in Algeria points to only two species as sufficiently hardy to be grown on a large scale—the *Eucalyptus globulus*, or blue gum, and the *Eucalyptus resinifera*, or red gum. The former is the better in every respect, but it does not stand the drought as well as the latter, and it has the unpleasant habit of dying suddenly, apparently without any perceptible cause, when it has obtained a considerable size. Consul-General Playfair recommends it in all cases where the ground is deep and fresh, or where irrigation is possible: in dryer soils, where there is no great depth of earth, and where irrigation is impracticable, the other should be selected.

CORRESPONDENCE.

NOTES ON MR. HOLLWAY'S PROCESS FOR THE UTILISATION OF SULPHIDES.

I wish to add some notes on the mechanical side of this subject, although these may, perhaps, be affected by the chemical necessities of the case.

It seems of the greatest importance to economise the fuel used for blast purposes in this process, especially where water power may be scarce, and fuel expensive abroad, and any such saving will enable even poorer ores than now to be profitably worked. Therefore, the air-blast pressure should be kept down to the minimum chemically necessary. For each pound of pressure per square inch of air blast saved, would, at the Rio Tinto mine, in Spain, be equivalent to a saving of £1,400 a-year in coals, besides some reduction in first cost of engines and boilers. And in order to keep down the air-blast pressure as much as possible, the depth of the molten material in the furnace or converter hearths must be as small as possible, since each 6 inches depth of molten bath requires about 1 lb. additional air-blast pressure per square inch.

Economy in air-blast will probably be effected (as proposed by Mr. Hollway) by first melting the pyrites ores and fluxes in suitably shaped blast furnaces, and then continuing the blowing of the molten portion as much as necessary in separate vessels, afterwards allowing the heavier regulus to subside, and the lighter slag to be drawn off in other further vessels, of course, with provision for condensing and collecting the sulphur, acids, and other valuable volatised products. A lower blast pressure also reduces the temperature of the furnace, and thus conduces to the durability of the lining, which is so difficult and expensive to maintain. The best shape for the blast furnaces should be carefully experimented on, so as to ease the blast, by carrying all the unmelted burthen of ore and flux on sloping sides of the furnace, for which purpose it is not certain that a circular section is the best. The position, direction, and inclination, number and size of the tuyère-openings should also be experimented on, to attain the best

results; for if the air can be blown down in to the molten mass, it need not have so great a pressure as if introduced from below, where it has to overcome the resistance or pressure due to the depth of the molten bath, where the chemical action is so rapid that the blast probably ceases to be air a few inches from the tuyère mouths, and this is an additional reason for reducing the depth of molten material of bath to the minimum possible.

The pyrites ore and flux should not be broken too finely, or else the unmelted burthen will fall in a mass on to the molten portion, and so necessitate increased blast pressure, and if the lower part of contents of furnace should ever get into a pasty, sticky, or choked condition, then the gases evolved, which ought to pass up through and heat the burthen, would be dangerously confined; in which case safety-valves, with openings at different levels, might be necessary to let off these gases, whose presence, if unrelieved, might otherwise increase dangerously. Such safety valves must be placed at a proper distance from the heat of the furnace, and must be of a material which will withstand the corrosion of the hot sulphurous acid gases. If the air-blast can be heated in the blast furnaces themselves, then the blast pipes must also be constructed of some durable material, or else protected by brickwork against the heat and corrosion.

The operation of the blast, &c., will also be facilitated by making the slag of as light specific gravity as the fluxes used will permit.

The heat from the slag should be utilised in heating the air-blast, in cases where the slag is not otherwise made use of, though slag such as Mr. Hollway's, which contains over 50 per cent. of iron, will, in some countries, well repay working, whilst hot, to extract this iron. But, if the slag be run direct from the furnace into shallow iron trucks lined with fire-brick, earth, sand, or other suitable material, and if these trucks be run into a closed chamber, gallery, or tunnel of brick or earthwork (with double doors at each end for the retention of the heat and for excluding the outer air), then the air in the blast-pipes would be considerably heated if such pipes were placed just over the trucks in this chamber, and if the air in them was passed backwards and forwards in them until sufficiently hot. If sufficient heat cannot be thus obtained for the blast, then its heating might be completed by utilising the waste heat of the blast furnaces. This system may be easily adopted at any iron or metal works where there is a supply of hot slag or of other hot materials (such as large castings or forgings) by the use of some such chamber, as all such heat, whilst cooling, is at present wasted.

If it should be desired to cast the hot slag into bricks, tiles, paving slabs, or other articles in moulds, this could be done on the trucks, which would then be put to cool in the closed chamber, where the air-blast (or the feed-water for boilers also) is to be heated. Of course, when cool, these trucks are run out, and others, with fresh hot slag, are introduced into the chamber.

The trucks should be shallow, so as to give as much heating surface as possible, and their sides may be slanted, so as to facilitate tipping out the cold slag. The dimensions of the chamber will depend on the pipes that can be placed in it, and on the number of trucks of hot slag used to attain the required temperature, but it should be of a shape to just hold a considerable number of trucks on the line of rail.

Another method of utilising the waste heat of the slag would be to run it out of the furnace direct into water, which could be thus heated sufficiently for use in the steam boilers, if it could be filtered properly from the dirt, &c., dissolved from the slag, which would be thus granulated.

Any such application and use of slag heat depends very much on the use (if any) to be made of the slag afterwards. This may, in turn, depend on questions of cost of fuel and of carriage to market of the articles thus producable from it, such as cements, bricks, silicate-cotton, &c.

Although only part of its heat may prove available, since slag is a bad conductor or radiator of heat, yet all such easy economies are worth consideration, where large industries are concerned, now that competition is so close, prices so low, and trade so depressed. And the only trouble and expense involved in such trial would be in the construction and working of the closed chamber, for which some existing building might possibly be made available.

Where there is water-power at hand, then the profits of such processes as Mr. Hollway's will be further increased, though such profits depend chiefly on the richness of the ores used on variable local circumstances, which affect working conditions, and also on the fluctuations in market prices of the metals, the sulphur, and the acids thus produced. A spare engine and boiler will probably prove useful in case of break-downs, and also to enable the blast to be varied, to suit changes of ores, &c.; and the best arrangements for putting the furnaces easily in and out of work, for repair, will be to place them in a circle with a central flue, to which their blast and gas pipes converge. They should also, where possible, be placed in a hollow, or near to a high bank, so as to save the cost of lifting all materials into them.

WALTER T. SHUTE, C.E.

May, 1879.

POSTING PROOFS.

The suggestion of your correspondent, "G. M. Necks," in your last week's issue, could not very well be acted upon, as persons might, without the knowledge of the clerk at the counter, stamp the proofs and never hand over the letters or put them into the post-box; besides all messengers sent with letters are not intelligent enough to make use of a machine, however simply designed for stamping.

If the Government finds that the general community are in favour of the scheme (and no opportunity has as yet been afforded them of fairly resorting to it) modifications and alterations, when in use, would readily and simply suggest themselves.

A. CLIFFORD ESKELL.

Grosvenor-street, May 13th.

GENERAL NOTES.

Invention of the Telephone.—Mr. S. H. Brackett, of St. Johnsburg Academy, Vermont, writes to the *Scientific American*, claiming for Mr. Edward Farrar, of Keene, N.H., the discovery of the principle of the telephone in 1851. In support of the claim, Mr. Brackett gives the following extracts from Mr. Farrar's correspondence of the time:—"Each reed of a melodeon is furnished with a small metallic point, which, while the reed is at rest, approaches near to the surface of mercury in a very small cup underneath the reed, into which the point dips when set in motion. The reeds are connected with one pole of a battery, and the cups with the other. The current is broken with each vibration of the reed. At the remote end of the wire is a temporary magnet, with an armature fixed upon a spring in near proximity to the magnet, and which is affected as a reed at the other end of the line is set in motion, the effect is that the armature vibrates with the reed set in motion, and, at the pitch of a sound depending on the rapidity of vibration, it will be the same in the reed and armature. A tune on the instrument will therefore produce a tune on the armature. What may appear somewhat strange, several different tones may be heard when chords are struck upon the instrument. The object of my inquiry was this: If the current power could be varied by some slight variation of a vibrator to be affected by the atmosphere as the tympanum of the ear is, the supposition is that the sounds of the voice might be reproduced by the means stated above."—*Nature.*

Singing in Public Elementary Schools.—A correspondent points out that the total for the year ending July, 1877-1878, was not given in the paragraph last week, and it amounted to £119,000.

Indian Tea Production—According to official statistics, it appears that there were, in 1876-77, 1,896 tea plantations in British India, which had 146,685 acres under tea trees; there were also 483,423 acres taken up for planting, but not yet planted. The total production of tea in the year was 29,557,482 lbs. The highest average yield in lbs. per acre of mature plants was 412 lbs., in Darrang; the next, 357 lbs., in Garhwal. The Assam Province gives the largest production, nearly 23½ million pounds.

NOTICES.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

PROCEEDINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday Evenings, at Eight o'clock:—

May 21.—"Edison's New Telephone." By Conrad W. Cooke, Esq. Prof. J. Tyndall, LL.D., F.R.S., will preside. [See notice—on page 523.]

The adjourned discussion on the paper on "The Government Patent Bill," by W. Lloyd Wise, Esq., Assoc.Inst.C.E., will take place on Tuesday next, the 20th inst., at eight o'clock.

African Section.

Tuesday Evening, at Eight o'clock.

May 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By Edward Hutchinson, Esq., Lay Secretary of the Church Missionary Society. Arthur Mills, Esq., M.P., will preside.

Chemical Section.

Thursday Evening, at Eight o'clock.

May 22.—"The History of Alizarine and Allied Colouring Matters, and their production from Coal Tar." By W. H. Perkin, Esq., F.R.S. Part II.

Indian Section.

Friday Evening, at Eight o'clock.

May 23.—"The Harbour of Kurachee." By W. J. Price, Esq., M.I.C.E. Sir William Merewether, C.B., K.C.S.I., will preside.

Cantor Lectures.

Third Course: Five Lectures by W. H. Preece, Esq., on "Recent Advances in Telegraphy."

Lecture V.—May 19.

Automatic and fast-speed telegraphy.

Members can admit two friends to each of the Ordinary and Sectional Meetings, and one friend to each Cantor Lecture. Books of Tickets for the purpose were supplied to all the Members at the commencement of the session.

MEETINGS FOR THE ENSUING WEEK.

Mon., May 19th...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. W. H. Preece, "Recent Advances in Telegraphy." (Lecture V.)
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Karl Hillebrand, "The Intellectual Movement of Germany from the Middle of the Last to the Middle of the Present Century." (Lecture II.)
Royal United Service Institution, Whitehall-yard, 8½ p.m. Mr. John Scott Russell, "Storm Stability, as distinguished from Smooth Water Stiffness."
British Architects, 9, Conduit-street, W., 8 p.m. Mr. John Honeyman, "Bills of Quantities: Their Proper Relation to Contracts."
Asiatic, 22, Albemarle-street, W., 3 p.m. Annual Meeting.
Victoria Institute, 10, Adelphi-terrace, W.C., 8 p.m. Rev. J. S. Whitmee, "The Ethnology of the Pacific."

Tues., May 20th...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Special Meeting. The Adjourned Discussion on Mr. W. Lloyd Wise's Paper on "The Government Patent Bill," will be resumed.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. R. Seeley, "Suggestions to Students and Readers of History." (Lecture I.)
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. John D. Griffith, "The Improvement of the Bar of Dublin Harbour, by Artificial Scour."
Statistical, Somerset-house-terrace, Strand, W.C., 7¾ p.m. Mr. John B. Martin, "Some Effects of a Crisis on the Banking Interest."
Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m
Zoological, 11, Hanover-square, W., 8½ p.m. 1. Prof. Owen, "Description of a portion of a Mandible and Teeth of a large Extinct Kangaroo (*Palæorchestes crassus*) from Ancient Fluviatile Drift, Queensland." 2. Mr. Martin Jacoby, "Descriptions of New Species of Halticidae." 3. Mr. P. L. Sclater, "A Fourth Collection of Birds made by the Rev. G. Brown, on Duke of York Island and in its vicinity."
Royal Colonial, "Pall Mall," 14, Regent-street, S.W., 8 p.m. Mr. Alexander Rogers, "Life in India."

Wed., May 21st...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Mr. Conrad W. Cooke, "Edison's New Telephone." [Special tickets required.]
Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Resumed Discussion on the Rev. W. Clement Ley's paper, "The Inclination of the Axes of Cyclones." 2. Mr. G. A. Hagemann, "Observations of the Velocities of the Wind and on Anemometers." 3. Mr. G. M. Whipple, "The Relation Between the Height of the Barometer and the Amount of Cloud, as observed at the Kew Observatory."
Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m. Annual Meeting.
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Sir Patrick De Colquhoun, "The Authorship of Shakespeare's Plays."
Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr. T. Pinches, "The Bronze Gates of Baliwat." 2. Mr. W. De Grey Birch, "Sculptured Stone in Ely Cathedral." 3. Mr. W. G. Fretton, "Antiquarian Losses in Coventry during a Century and a Half."

Thurs., May 22nd...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Chemical Section.) Mr. W. H. Perkin, "The History of Alizarine and Allied Colouring Matters, and their Production from Coal Tar." (Part II.)
Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "Dissociation." (Lecture IV.)
Inventors' Institute, 4, St. Martin's-place, W.C., 4 p.m. Annual Meeting.

Fri., May 23rd....**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Mr. W. J. Price, "The Harbour of Kurachee."
Royal United Service Institution, Whitehall-yard, 3 p.m. Lieutenant W. H. James, "Modern Rifle Fire, its Effects on Armament, Training, and Tactics."
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. W. H. Preece, "Multiple Telegraphy, or Duplex and Quadruplex Telegraphy."
Quekett Microscopical Club, University College, W.C., 8 p.m. 1. Mr. C. Spencer Rolfe, "Some Improvements in Microscopical Turn-Tables." 2. Mr. J. W. Groves, "Stained Sections of Animal Tissues, and how to Prepare them."
Clinical, 53, Berners-street, W., 8½ p.m.

Sat., May 20th....Workmen's Social Educational League (at the House of the Society of Arts), 3 p.m. Annual Meeting.
Linnean, Burlington-house, W., 3 p.m. Annual Meeting.
Physical, Science Schools, South Kensington, S.W., 3 p.m.
Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Henry Morley, "Swift." (Lecture I.)

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,383. VOL. XXVII.

FRIDAY, MAY 23, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

The Fifth and concluding Lecture of the Third Course of Cantor Lectures, on "Recent Advances in Telegraphy," was delivered on Monday, the 19th inst., by Mr. W. H. Preece.

The lecture dealt with automatic and fast speed telegraphy.

The Lectures will appear in the *Journal* during the summer vacation.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

The annual Conference on National Water Supply, Sewage and Health, was held in the Rooms of the Society of Arts, on Thursday and Friday, 15th and 16th inst., the Right Hon. JAMES STANSFELD, M.P., late President of the Local Government Board, in the chair.

The following resolutions were passed:—

1. That this Conference wishes to express its entire satisfaction at the action taken by His Royal Highness the Prince of Wales, President of the Society, in applying to the Government for the appointment of a Royal Commission to inquire into the Water Supply of the country, and earnestly hopes that the Government will take steps, without any delay, to carry into effect the resolutions passed at the meeting held last year.

2. That since a comparatively minute quantity of the poison contained in the evacuations of enteric fever patients may, it is believed, when subjected to conditions favourable to the development of that poison, lead to the specific infection of very large volumes of water to which it has gained access, all possible sources of excremental contamination, in the vicinity of water-courses, should be rigidly dealt with during the construction or repair of such water-courses, and in their use.

3. That this Conference recommends the Council to arrange that a deputation wait upon the Government, to urge the necessity of taking further legislative measures to prevent the continuance of the pollution of the Thames by sewage.

A full report of the proceedings of the Conference will be published in the *Journal* as soon as possible after the report of the discussion has been corrected by the speakers.

CONVERSAZIONE.

The Society's *Conversazione* is fixed to take place at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education) on Wednesday, the 25th of June. The cards of invitation will be issued shortly.

THE PATENT BILL.

The following Memorial, on the Patent Bill introduced by the Government this Session, has been presented by the Council of the Society to to the Home Secretary:—

TO THE RIGHT HONOURABLE THE SECRETARY OF STATE FOR THE HOME DEPARTMENT.

The Humble Memorial of the Council of the Society for the Encouragement of Arts, Manufactures, and Commerce, founded in 1754, and incorporated by Royal Charter in 1848.

The Council of the Society of Arts desire to express by this memorial their hope that the Bill brought in by yourself, the Attorney General, and the Solicitor-General, for the consolidation, with amendments, of the Acts relating to Letters Patent for Inventions, may, with (or even without) certain modifications which in the judgment of the Council would improve it, become law during the present Session of Parliament.

The Council of the Society of Arts, deeply interested as they are in everything which tends to the promotion of invention and of manufacturing industry, have long felt, in common with others of her Majesty's subjects, that the present condition of the Patent-law is unsatisfactory, and for this reason among others, that the legislation concerning patents is contained in no less than seven different Acts of Parliament.

Your memorialists are therefore desirous that the present Bill should pass, so that patent legislation may be brought into one comprehensive Act, and to remedy those other matters in the present condition of the law which it has long been felt should be altered. This Bill, as it stands, already provides for many such alterations, and is therefore, in the opinion of the Council, one which ought certainly not to be allowed to miscarry.

The Council desire to be permitted to express the satisfaction with which they view many of the changes proposed in the Bill as drafted. They also desire to be allowed to represent, as above stated, that in certain details they believe the proposed measure might practically be improved.

The Council now propose to refer in order to the clauses in which they consider modifications are desirable.

Clause 5. The Council observe with regret that none of the extra five Commissioners to be appointed are to be paid, but they are of opinion that at least two should be paid, and should be required to devote their whole time to the conducting of the business of the Patent-office.

Clauses 7, 8, 9. The Council gather from the language of these clauses, that it is intended, in framing the rules which determine what is the "prescribed time," to so frame them that

the prescribed time will extend beyond the limit of the time during which the provisional specification is kept secret, and they fear that oppositions will consequently be conducted upon open documents. The Council know that, on a cursory consideration, most persons would urge that such an opposition would be better than one conducted as at the present time, and that the proposed mode is more logical. But they believe that the expense of oppositions conducted upon open documents, and the time occupied upon them, would be nearly equal to the expense of money and time devoted to the trial of a patent action, and that in this way, the intended saving to the poorer inventors by the reduction of fees will, in many cases, be more than neutralised by the heavy additional expense attending the resisting of an opposition. And further, the Council fear that, looking at the occupations of the Law Officers of the Crown, who have to hear these oppositions, there must necessarily be great delay in obtaining appointments, when the time to be occupied in the hearing is so much extended, as it will be if the opposition be conducted upon open documents.

Clause 15. The Council gather from this clause that it will still be possible for an inventor, who has obtained provisional protection on a day subsequent to that on which a protection was granted to another, to obtain precedence in certain cases by having his patent sealed at an earlier date than that at which the original applicant applied for the seal. The Council are of opinion that, for all purposes, the date of a patent shonld be reckoned from the day on which the provisional protection was granted; they think it extremely undesirable that, under any condition of things, the position of a person who has obtained provisional protection on a certain day should be prejudiced by the fact that some subsequent applicant for provisional protection had obtained the seal at an earlier date than the first applicant; the Council, moreover, desire to call attention to the fact that, if it be possible by the earlier obtaining of the seal to get some advantage in point of date, it would be a temptation for the patentee not to make the full use of the term of provisional protection (which, by this Bill, is extended) for the purpose of enabling him to perfect his invention.

Clause 16. The Council observe that the Bill proposes an extension of time from 14 years (their present limit) to 21 years, and presume that this extension has been accorded as a compensation for the withdrawal of the present power of applying to the Privy Council to recommend her Majesty to prolong the term of the patent. In the judgment of the Council, the extra seven years is, taking all patents one with another, too large a measure of prolongation, because it will be to the benefit of every patentee; not only those who have not been sufficiently remunerated at the end of the 14 years, but also those who have; whereas, at present, the power of applying for prolongation is one that relates only to the unremunerated patentee. Under these circumstances the Council would have been glad to see the power of prolongation preserved, had there been any tribunal of an entirely satisfactory character to deal with the question of prolongation. Assuming, however, that under the circumstances it is desirable to do away with the power of applying for prolongation of a patent in favour of those persons who have not been sufficiently remunerated, the Council would suggest that the extension of all patents from 14 to 17 years (the term in the United States) would meet the needs of the case.

Clause 19. The Council are of opinion that there can be no need, on the ground that a patent is obstructive, to make the patent voidable after three years, on the ground of its not being prosecuted either by the patentee or by his licensees, when there is power proposed by the same clause for all persons demanding them to obtain licenses from the patentee. With respect to this question of obtaining licenses, the Council are inclined to apprehend that it might operate as a bar to the taking up of an invention by a manufacturer, who, after having embarked upon the patentee's invention, and having brought it into practical notice, might find himself in competition with those who have not incurred the same risk and expense; they fear that in this way inventions might lie dormant which, in the absence of such a provision for compulsory license, might be put into exercise by some one person who felt that, if he did proceed, he would enjoy the undisturbed fruits of his enterprise. The Council, believing that great harm may result from a wholly unguarded use of the compulsory licenses clause, would be glad to see the insertion in this clause of the words which were in the Government Patent Bill of the year 1877, to the effect that licenses should only be obligatory upon its being proved to the Lord Chancellor that they were needed.

Clause 24. The Council strongly advise that Clause 24 should be struck out, as they are of opinion it is desirable to deal with foreign inventions precisely upon the same terms as English inventions are dealt with; and they are further of opinion that the duration of an English patent should not be affected by the cesser of a foreign patent for the same invention.

Clause 44. The Council view with some regret the extension of the existing powers of the Commissioners of Patents in the present Bill, as they notice that there are very many points definitely provided for in the Act of 1852 for which in the present Act it is left to the Commissioners to make general orders. The Council are led to this conclusion by their conviction that certain recent changes in the Patent-office, especially in connection with the publication of specifications, have not been to the advantage either of the public generally or of inventors, having apparently been made rather with a view to economy than to efficiency. The Council are strongly of opinion that, considering the large revenue derived from the Patent-office, the first object in carrying out its business ought to be to provide every possible facility to inventors, and that the earning of revenue should be quite a secondary consideration. The powers given to the Commissioners under these clauses appear to be very extensive, and, until they are better defined, the Council hardly feel able to offer any opinion upon them beyond that above expressed.

Clause 47. The Council desire, in respect of this clause, simply to suggest that there should be certain alterations made in the date of payment, in accordance with their previous recommendation

that the duration of the patent should be for 17 years instead of for 21.

Signed on behalf of the Council of the Society for the Encouragement of Arts, Manufactures, and Commerce, this 17th day of May, 1879,

ALFRED CHURCHILL, Chairman of Council.
H. TRUEMAN WOOD, Secretary.

ADJOURNED ORDINARY MEETING.

Tuesday, May 20th, 1879; A. H. BROWN, M.P., Vice-President, in the chair.

The discussion on Mr. Lloyd Wise's paper, on the Government Patent Bill, adjourned from the 7th inst., was resumed.

The Secretary said he had received letters from several gentlemen who were unable to attend, expressing their regret thereat, amongst others, Mr. Mundella, M.P., Mr. Dillwyn, M.P., Sir Antonio Brady, Prof. Goodeve, &c., but he did not think it necessary to take up the time of the meeting by reading the letters.

The Chairman then called upon Mr. G. Anderson, M.P., to commence the discussion, by reading a paper which he had prepared, in order to bring before the members a summary of Mr. Lloyd Wise's paper.

Mr. Anderson said—I have been asked by the Council of your Society, to open the discussion on the Patents Bills to-night, and I think I cannot do so better than by giving a brief summary of the excellent paper read by Mr. Lloyd Wise, on Wednesday, the 7th, which paper went minutely over all the clauses of the Bill, and expounded their details. These were too extensive for full discussion on one evening, and, even on this second night, it seems more likely to lead to practical results if we confine ourselves, as far as possible, to the larger and more salient points of the proposed change in the law. The proposal to increase the number of unpaid Commissioners by five additional ones is condemned by Mr. Wise, on the ground that suitable men cannot be found to do really good work without remuneration, and that the bare honour of the appointment is insufficient inducement. The "provisional protection" given on application is extended to twelve months, but not less than three months before its expiring, the applicant must file a complete specification, or he would be held to have abandoned his application, and the provisional protection would cease. The Commissioners are then to publish the specification and other documents relating to the application, so that the applicant has all his secret revealed before he knows whether he is to get a patent or not. This provision Mr. Wise condemns. He says, "although the present system of opposition on closed documents has its inconveniences, they are not, in my judgment, so grave as to justify the opposite extreme of throwing open to the world the whole of the inventor's secret, the result, may be, of much thought, time, and expenditure, before giving him any grant." Again, "to make the whole thing public, and then refuse the grant, would be not only manifestly unjust, but also inexpedient, for it would tend to induce suppression of material information in specifications. Intending patentees would very naturally reason that, to disclose all the secrets of, for instance, a new process of manufacture, before being assured of some exclusive enjoyment, would be suicidal. It would be probably more remunerative to take the risks of trying to work in secret." Mr. Wise condemns this provision also on the ground of its being calculated to invite litigation, and therefore, to add to costs, and be almost prohibitory to inventors of limited means; and he answers the argument that patent property would gain in standard of value when there was such difficulty in obtaining it, by saying that those of least real value would meet least opposition, and be easiest obtained; therefore, raising the standard of value would be rather a questionable advantage. At present, if the law officer reports against sealing a patent, there is no appeal, but the Bill proposes to give an appeal by petition to the Lord Chancellor. Mr. Wise considers this a valuable concession, but he does not so consider the right to petition against the sealing, as it is an additional means of obstruction put in the power of opponents, and unnecessary, when the patent is also to be revocable on petition to the Lord Chancellor, with sufficient ground shown. The date of the patent is to be from its sealing, or some date between the application and the sealing, the effect of which might be, that of two applicants for the same patent, the latter of the two might be the first to file the complete specification and gain the sealing, and the earliest applicant would thus be cut out, which would not be the case if the patent were made to date from the application. The extension of term to 21 years Mr. Wise considers a great boon, as the present system, which allows a patentee on the expiry of his 14 years to apply for a prolongation for some term not exceeding other 14 years, is so costly as to render it unavailing in those very cases where it is most needed. Mr. Wise, however, omits to observe that, while by the present Bill, this privilege of application for a prolonged term is taken away from existing patents, the extension to 21 years is rigidly kept back from them, so that, while the proposed extension is a boon to future patentees, existing ones will be actually put in a worse position than they now are, being deprived of their present privilege as to extension of time, and denied the new one. A provision is introduced to enable a patentee to add to his specification any supplementary invention, provided it be such as, if known at the date of the application, might have been properly comprised in the specification. Mr. Wise approves of this provision, as, in the course of developing a patented invention, improvements may be made not sufficiently important to be worth patenting separately, and yet of great practical value. There is a provision for the use of patents for the service of the Crown, not without payment, but the rate of payment to be fixed by the Treasury. It is objected to this, that in such a case the Treasury is not an impartial judge. It is also objected that inventions patented by servants of the Crown are to be taken advantage of by the Crown without payment. One provision that has been much objected to, is the one making a patent liable to revocation, if, at the end of three years from its date, the inventor fails, by himself or his licensees, to use or put it in practice, or to make reasonable efforts to secure its use or practice, or if he refuses to grant licenses on terms which the Lord Chancellor considers reasonable. Mr. Wise expresses the opinion that such a provision as this would import great uncertainty into patent property, and that it would prove unworkable here, as it had proved in Germany, where a similar provision had been abandoned. The Inventors' Institute at Glasgow also object to this clause, but not strongly, if the term were made five years instead of three. As the usual object of a patentee is to have his patent extensively used by the public, this provision seems unnecessary, unless it can be shown that patents are taken out for the purpose of excluding the public from the use of inventions on reasonable terms. The provisions relating to imported inventions, Mr. Wise considers to "contain a strange mixture of good and bad features." In such cases the patent here is only to be to the foreign patentee or his agent, and he must apply within six months from the date of the foreign or colonial grant, which seems tantamount to saying that if the British

public does not get a valuable invention imported within six months, it had better not have it at all; for if we refuse to give any reward for importing it after that term, the chances are that we may not get it at all, and, moreover, by this rule, if once an invention is patented abroad, it never can be patented in this country, even if independently invented here. Another disability about imported inventions is, that a patent for them is not to run for our period, but only for such time as the shortest of the foreign patents obtained for it runs. The proposal to require a deposit of models Mr. Wise condemns, as he says he has frequently known the model to cost more than the patent, but this was in America, where the cost of a patent is only 35 dollars; still it would be a great burden to inventors in this country also, especially in the case of complex machinery, and its utility would be very questionable. The stamp duties by the new Bill reach £12 10s. for the application and patent; £50 additional to be paid at the end of the third year; £100 at the end of the seventh, and a further £100 at the end of the twelfth. Mr. Wise condemns these duties as too high, and urges a reduction. The Glasgow inventors object to any payment at all at the third year, on the ground that in most cases an inventor has barely perfected his invention then, and has very rarely realised any profit at all from it. They also urge the reduction of the payments at the seventh and twelfth years to £50 each, on the ground that these payments would be abundant to cover costs, and that the Patent-office ought not to be made a source of surplus revenue. Indeed, there is room for doubt if even these payments are not too high, as they would still be so far in excess of what in other countries is found sufficient. Those who had the advantage of hearing Mr. Wise's able paper will remember how much more complete were its criticisms of the provisions of the Bill. The object of this is in no sense to supersede the other, but rather only to summarise the salient points, so as if possible to concentrate the discussion upon these. I almost entirely agree in Mr. Wise's criticisms, and if I may be allowed to add a few words, it would be to point out, that while this Bill is an improvement on the previous Bills of the present Government, it is still, like the others, tainted with a spirit of jealousy of patentees, and treats them as having, or desiring to obtain, interests hostile to the public, and it shows that the Government fail to take the broader view that the real interest of the country, and especially of the manufacturing industries of the country, is to have inventions, and that the way to get inventions is to stimulate the inventive genius of the people by a liberal Patent-law, as has been done with such marked success in America. The Government Bills, however, have been four in number, and each has been better than the preceding one, thereby justifying the wisdom of those who refused to accept them. The Government have shewn on this question a spirit so commendably progressive, that further concessions seem not at all impossible under a further judicious opposition, and the opinion of the Society of Arts ought to, and probably will, have great influence in modifying present views; and I would suggest that whatever resolutions are arrived at should be communicated formally, by memorial or deputation, to the Lord Chancellor and the Attorney-General.

Mr. Hinde Palmer, Q.C., said that, having served on the Select Committee of the House of Commons for the two sessions of 1871 and 1872, upon the question of the policy of the Patent Laws, as well as the administration and working of the laws, he had naturally taken considerable interest in the subject. The appointment of the Committee was made at a time when there was a very strong feeling expressed, both in and out of Parliament, not by a large body of persons, but by some very influential gentlemen and others, against patents altogether. There was a strong feeling then pervading some portion of the public in favour of the total abolition of patents; it was thought at that time by all persons, that the appointment of the Committee would be of great use in dealing with the whole subject of the policy of the protection of inventors. He might congratulate those in favour of protection upon the effect which the appointment of the Committee had, because the effect was to establish the policy of maintaining the present protection for inventors in this country. Since that time, the agitation for total abolition had very materially moderated, in fact, it had almost subsided. He recollected the agitation had got to that height, that a large meeting was held among the working men in Clerkenwell, at which Lord Selborne was to preside, for the total abolition of patents, but the result of the meeting was rather humorous, because those who came to support total abolition altered their minds upon the matter, and carried a resolution in favour of continuing patents. It would not be for him to say that the agitation had totally subsided, or, at all events, that the abolitionists had been entirely convinced, because he saw present some gentlemen who entertained a view rather opposed to the existence of patents, unless patentees were rewarded for their inventions in some other mode than by granting them patent rights. But, be that as it may, they had now to deal with the Bill of the Attorney-General, and Mr. Anderson had very justly said that this Bill was a great improvement upon all former attempts made by the Government to improve and amend the Patent-law; that it showed the good effects of a constant and persevering opposition, and of not accepting from the Government what they at first proposed to give. The present Bill was, no doubt, a great improvement, but it had the objection which had been pointed out by Mr. Wise, and recapitulated by Mr. Anderson, for it struck him that the policy of any Government or Legislature ought to be, not to throw obstacles and obstructions in the way of granting protection to inventors, but, if possible, to encourage as much as possible the inventive genius of the country. In accordance with that view, he thought the simplest process was the best. They ought not to subject inventors to the great expense to which they were now put in order to obtain patents in this country, viz., to the sum of about £175, which it cost to get a patent completed. At one time, he ventured to introduce a Bill for the improvement of the law, one prominent feature of that Bill being to cut down the expenses by one-half, and he was not at all sure that that was sufficient for the purpose. Though that was the principle upon which they were to proceed, the question was whether the present Bill did that in an effective way. He was surprised to find, on looking at the Bill, how much more simple it was in all its procedure, because the former Bills provided for a staff of examiners, and of a preliminary examination on the provisional specification, to be conducted by those examiners. Those half dozen clauses in the Bill were now all struck out, and there was to be no real examination until the filing of the complete specification. Great objection was made to the examination before the law officers upon filing the complete specification; it was said, supposing the patent is refused after the inquiry has taken place, a great hardship will be done to the patentee by the publication; and at first sight that did strike one as a very serious objection. It might be said that was precisely the process provided by the Bill of 1852, if the inventor chose in the first instance to lodge a complete specification, instead of going through the process of provisional protection, because one of the clauses of the Act of 1852 stated that, upon depositing a complete specification, the thing should be made public; notice of opposition should be given as provided by the present Bill, and then the contest takes place before the Attorney-General. It struck him that, unless they were prepared to grant patents to everyone who came just for the asking, and to abolish all investi-

gation previously, they must have some investigation as to the nature of the application. Some people were in favour of granting patents indiscriminately without previous inquiry, but he should not think that was the better opinion, nor was it entertained by people who had devoted attention to the subject. The inquiry ought to be an effective one; but up to the present it had been an inquiry in the dark, because an objector did not know what he had to object to previous to going before the law officer. It had been said by the late Mr. Thomas Webster that it was nothing more nor less than a farce, and it stood to common sense that it was nothing else, because a person could not object unless he knew what he had to object to. Under the new Bill this would be altered, because an objector would go before the Attorney-General with full knowledge of the subject, and the matter could be fairly discussed. He was free to admit that, if you allowed the inquiry to go to any extent—as to the utility of the invention, and such like things—it would be a serious matter to allow the Attorney-General to make public all the proceedings, and afterwards to refuse a patent on that ground. He was very much inclined to think that the grounds of the objection ought to be defined; because, when they had to deal with the preliminary inquiry on the provisional specification, the difficulty had always been to determine to what extent the inquiry ought to go. At one time, it was proposed it should go to the novelty of the invention, to its utility, and so on; but, some feeling being shown upon the point, that was struck out in the Session of 1877, and it was provided that the inquiry upon the provisional specification should be as to its being an invention within the Statute of Monopolies, and whether it sufficiently described the invention. If they were to have an inquiry before the Attorney-General, which was really substituting the inquiry with proper materials for the inquiry in the dark, they ought to restrict and define in some way the extent to which the opposition should go, and the grounds upon which it proceeded. It being proved to the law officer of the Crown that there was no novelty in the invention, it would be a mercy to the patentee to decline to grant a patent, and, under those circumstances, he could not see that any grievous injury would be done by the publication of the proceedings before the Attorney-General. Some gentlemen thought it would be a desirable thing to grant patents, even after refusal, with a kind of notification that they had gone through an ordeal and been subjected to a refusal, but others held a different opinion. It appeared to him that, to grant a patent under such circumstances, with an obvious stigma attached to it at the beginning, would tend very much to lead the inventor into costly litigation. If the inquiry took place upon a complete specification, purporting to give full particulars of the invention and how it was to be worked, he believed it would be greatly to the advantage of the public as well as to the inventors. Another important question, which had received considerable attention, was the granting of compulsory licenses, and although the committee thought it would be desirable to have such a provision, he was by no means of opinion that it would be proper, because it was interfering with the rights which a patentee had acquired in his invention. A strong argument used in favour of it was, that when a patent was granted for a certain invention, some one came with improvements upon it, but was at once stopped by the original patentee saying, you cannot make your patent available unless you adopt my invention, and the moment you do that you are infringing my patent. The improver would say, If that is the case, grant me a license to use your patent, so that I may complete my invention and obtain a patent for it. When Mr. Newton, who was a most eminent patent agent, gave evidence before the committee, he suggested that as a strong reason why there should be power to grant compulsory licenses; but the difficulty was to fix the proper remuneration of the patentee for granting them. The Bill proposed that the question should be settled by the Lord Chancellor, but he did not think he was the proper person to be entrusted with the task, and would himself much rather leave it to the Commissioners. It might be settled by arbitration, but in the event of that not being accepted, then it should go before the Commissioners. The provision for compulsory license might be rendered useful, to avoid the inconveniences to which manufacturers were subjected by the introduction of new patents, of which they were not aware. What struck him as being the most forcible argument in favour of compulsory licensing was the obstruction which would otherwise be put in the way of any one applying for an improvement upon an existing patent, unless the prior patentee could be compelled on fair terms to grant a license. With regard to the reduction of expenses, the committee to which he had before referred, resolved that the tax should only be sufficient to pay the legitimate expenses of the Patent-office, and that anything beyond that was unjustifiable. No doubt all were aware that the law officers of the Crown, previous to Mr. Gladstone's Government, were each in receipt of some £5,000 or £6,000, arising from patent fees; that had now been altogether abolished, and a salary substituted, which would doubtless facilitate any amendment being made in the law. What took place now? In 1877, the surplus income, beyond what was necessary to pay all the legitimate expenses of inventors and the Patent-office, amounted to £183,720, and that surplus went, not for the benefit of individual inventors, but to the Consolidated Fund. He protested against that altogether, because he thought they ought to facilitate as much as possible the acquisition of patents, especially by poor inventors, from whom a large number of the inventions which had raised the country to its great importance in manufacturing industry had sprung; therefore they ought to lower, as much as possible, the tax, and he saw no limit which they would be justified in putting upon the taxation, except that which would make it sufficient to bear the legitimate expenses of the patent and the patent administration. The aggregate amount of the sums carried to the Consolidated Fund, during a series of years down to 1877, amounted to £1,600,000; and the present Bill did not propose to deal with that matter. The Government Bills had been gradually reduced in extent and operation, and had very nearly come to this, that if you were to carry into effect the Act of 1852 as it stood, without making any alteration in the present law, you would do very nearly as much as all these Bills proposed to accomplish, and there were many gentlemen who thought that, rather than have these Bills at all, it would be better to leave the Patent-law as it stood instead of attempting any further legislation; and he was very much inclined to come to that opinion himself. The Chairman would no doubt tell them there was very little prospect of the Bill being carried during the present Session, and perhaps not during the present Parliament. One difficulty they had in carrying the former Bills into law was that the Government proposed to start a large class of paid examiners, but the present Bill struck all that out; and when one looked at what was left of the present Bill, and compared it with what might be done under the Act of 1852, it would be seen that the thing might be as effectively worked under the existing law as under the new Bill. No doubt there was one provision which could not be accomplished, namely, the extension of the term to 21 years, without any legislation. That was a great boon to all inventors, and a very proper one, and he should be glad if it could be secured under the law as it stood, but it could not. After the declaration on the part of the Government, in a Bill brought in by them, that 21 years ought to be the term

for which patents should be granted, persons would have greater facilities for getting an extension of the 14 years from the Privy Council than at present existed. He believed if they could see their way to giving a fair chance to the Act of 1852, as it now stood, by appointing an effective Commission, they might do a great deal more, and perhaps much better, without any legislation at all, than they would be able to do under the Bills which were being from time to time introduced. The action taken by the Society of Arts, from the first to the last, in encouraging the improvement of the various Bills introduced by the Government, had been attended with very good results, and, if persevered in, would improve the present Bill; though his present opinion was that they could do with the law as it at present stood. As he had mentioned that it would be right to give the Act of 1852 a fair trial, which had never been done, it was only fair that he should say that he believed Lord Alfred Churchill, the President of the Society of Arts, had headed a deputation to the Lord Chancellor, or presented a memorial from the Society, pressing upon his Lordship the propriety of carrying into effect the provisions of the Act of 1852. That fact showed that the Society had been most active in the matter, and the public ought to be most grateful to the Society for the facilities it had afforded for aiding the improvement of the law and the encouragement of inventive genius.

Mr. E. A. Cowper said—In a discussion such as the present, on a new Patent Bill, to sweep away the Patent-law of 1852 and all other Patent Acts, it is necessary to examine both the Acts themselves, so far as their words go, and also appreciate what has been done, or may be done, under such Acts, before we can come to a just conclusion whether it is wise to make the change. Now, having seen a good deal of the working of the Patent-law, and the want of its being worked properly, I must say that, of all the inconveniences and evils that have arisen since 1852, that of the want of one or more paid Commissioners has been the greatest, and the cause of most of the dissatisfaction that has arisen. I do not mean to trespass upon your time by going through, in detail, all the various matters, but I will put it to you all, as business and scientific men, if you wish to have an extensive office well managed, and particularly one where thought and judgment have to be exercised, would you not consider it but common prudence—and, in fact, a necessity—if that office were to work well, to appoint a paid person or persons to manage and conduct the various branches of the office, giving them power, of course, to do so? Now, the framers of the Patent-law of 1852 considered all this, and knew that it was necessary to have persons in authority so to conduct the Patent-office and the granting of patents, and the Patent-law of 1852 enacts that the law officers of the Crown (not by themselves, but) together with such other person or persons as her Majesty shall appoint, shall be the Commissioners of Patents. Now had this wise law been put in practice, and proper paid Commissioners appointed to manage and control the Patent-office, we should not have had the trouble that there has been in past years, even to get a library to sit down in to read the specifications and books in the office. The Patent-law of 1852, however, did not lay down sufficiently distinct rules and regulations for the conduct of the office, and in consequence it has been impossible, with all the pressure that has been brought to bear at various times, to get proper indexes, abridgments, and catalogues printed for the use of the public and inventors, notwithstanding the enormous annual surplus, over £100,000, and the accumulated surplus of sixteen times that amount. This abuse is untouched in any way by the proposed Bill. If, indeed, everything that could be done, had been done to make the office good and complete, with full accounts of foreign machines and processes, &c., then the surplus should be devoted to reducing fees to some extent, though not to so low an amount as some have spoken of. Now, if the Patent-law of 1852 was vague and wanting in definite rules and regulations to ensure the proper conduct of the office, let us turn to the proposed Bill now before Parliament, and see if it is more definite in its provisions. Although it is impossible that the Bill can be passed this Session, as no Bill of such importance ever was or could be passed without being first referred to a committee to take evidence on its clauses, still, as we have it for discussion before us, we must consider it as though it might be put forward and passed, even if it is premature to go into it this Session. Now, I at once say, what has been my opinion for this last 20 years, viz., that the policy of stimulating invention, by giving a patent for 21 years, is a wholesome thing, and is to the interests of the public and the inventor, if it were made a certainty that 21 years would be granted, for it is now universally admitted that it is largely by producing improvements that this manufacturing country has kept to the front in point of industry and wealth; and we must be very careful to keep moving, or we shall still hear of most inventions coming from America, as has recently been the case. It is true that individuals in America do sometimes damage themselves, or even ruin themselves, in prosecuting new inventions, but they so freely try new things (not being obstinate in keeping in old and deep ruts and grooves), that the manufacturers in America progress much faster than our manufacturers here, as witness all the small arms machinery, sewing machinery, watch machinery, &c. Now, together with well stimulated invention, our manufacturers should be enterprising, and instead of each one waiting in hopes that some other manufacturer may go first, and so be the pioneer, each one for himself should push forward to be the first in his own business with the very best improvements. I now come to three very important points, in which I consider the proposed Bill would lamentably fail to produce any improvement. Firstly, the five new Commissioners of Patents are to be unpaid, as distinctly stated on the first page of the Bill; if instead of this there had been three paid Commissioners appointed there might have been much done. The experiment has been tried of appointing persons as Commissioners who have their time fully taken up by other matters, and with the results we have seen, viz., the Patent-office being utterly neglected and left to a "superintendent," who had no authority whatever to make improvements which he could see from day to day were most urgently needed. The Commissioners have frequently not met for many months together, so that they have not even had the opportunity of informing themselves of what has been required, and now it is proposed to appoint five men, who would have no interest to attend to the work of the Patent-office from day to day, as is necessary; I say, therefore, that this would be no improvement on the present law. Secondly, the proposed Bill does not prescribe clear rules and regulations of a definite character for the conduct of the business of the office; it is not enacted that there shall be a thoroughly good "subject letter index," a "chronological," and an "alphabetical index," a "catalogue of foreign patents," proper "abridgments of specifications," and other details that I will not trouble you with now, but which are much wanted, for the proper conduct of the Patent-office; but I will name one other, and that is that a much larger and better library, for the perusal of books, is urgently needed, and if anything was wanted in order to prove the necessity of a better library, it is the fact, that books referred to every day by numerous readers (and the room is often full) are put away high up out of reach, thus requiring a high ladder to enable readers to get at them; indeed, sometimes a person cannot get at them from not being able to mount a high ladder. So wanting in rules and regulations is the new Bill, that even the bad practice of providing models with specifications might be intro-

duced by the Commissioners, and the very date of patent would depend upon the Commissioners instead of being, as it should be, the date of application. It would appear by the Bill that one patentee could overtake another, and get his patent dated as of the earliest date of the two. It seems doubtful also, whether oppositions are not to be conducted upon open documents, than which nothing could be much worse, and this is indeed a matter in which the new Bill would not work unless the Attorney and Solicitor gave up a large amount of their duties, to attend to oppositions, as they would be numerous and tedious, and, I am afraid, sometimes not altogether honest. Opposition often arises from some one having got a notion of what another man is about to patent; but if the whole of the invention of a would-be patentee is to be thrown open to an adversary, models might be made and much trouble given, in fact, the greater part of the proceedings of a trial would have to be gone through, to the great discouragement of inventors, and leading to the old and most objectionable plan of secret working, with men sworn to secrecy, &c. Any person being allowed to oppose, whether interested or not, is most objectionable, and opens the door to manufacturers to oppose as a matter of business. Thirdly, far too much power is proposed to be given by the Bill to the Lord Chancellor and the Commissioners, indeed, so much power, that no patentee shall be allowed to make his terms with a customer, without being liable to that customer going to the Lord Chancellor, and getting him to say how little profit he shall make, or how many persons he shall grant licenses to, even to the destruction of his own business, which he may have built up on his patented invention; it is really too ridiculous to imagine that such robbery would be contemplated in this free country, where at least the laws are framed with a respect of property; it is exactly on "all-fours" with the case of Cyrus and the two coats, which he made the two boys change, because one said the other's coat fitted him best, although the owner of the coat most strongly objected. I trust the House of Commons will stop such mis-appropriation of property. The Lord Chancellor has no time whatever to become a valuer of property, and even if he had, how is he to judge of the commercial value of inventions, even before being put in practice? The inventors and manufacturers themselves, although intimate with the trade, often make great mistakes as to the value of an invention, and it is not until it has been practically brought to bear, generally at great expense, that any true valuation can be put upon it; and when this has been done, is the patentee, who is thus a public benefactor, to be robbed of the results of his genius and perseverance by rivals in business? This power given to the Lord Chancellor, or to the Commissioners, would be fatal to the patent system, as some opponents to patents have not been slow to find out, and, therefore, advocate such a Bill. The power given to the Lord Chancellor to revoke a patent at the end of three years, if he does not think it has been worked on, is another instance of arbitary authority tending to destroy the patent system. I refer to paragraphs 14, 15, 19, 32, 33, 39, 43, 44, and 46 as being particularly objectionable, but the whole Bill shows such jealousy of patents, that I fear the practice of it would be fatal, and for these reasons I decidedly prefer "rather to bear the ills we have, than fly to others we know not of"—particularly as we well know, that if the present Patent-law of 1852 be fully put into practice by the intelligent action of three paid Commissioners, all would be well.

Mr. Coryton rose with considerable diffidence, knowing that his views were diametrically opposed to those of most present, but he had arrived at them after much experience in the working of the law. It was difficult to understand how anybody could, after the admissions which had been made on all hands, uphold the existence of the present state of affairs. Mr. Cowper's remarks applied to most inventors, and that gentleman might himself be taken as a fair sample of the class. The present system of granting patents was altogether objectionable, and he hoped the present Bill would pass, because nothing less than a state of chaos had prevailed ever since the Act of 1852 had been in force. It had been said, that Government appeared to evince jealousy of patentees, as persons whose interests were opposed to those of the bulk of the people, and among that public were the men who had been beaten by the patentee, it might be, "just by a neck," so to speak. That that was often the case would be within the knowledge of all acquainted with the state of manufacture in this country. The proposed Bill ought to receive the support of the Society, as leading (he hoped) to the ultimate abolition of letters patent altogether. Justice could not really be done by any legislative enactment, and it would be better to give up all attempts to legislate on the subject. No man was ever fourteen years a-head of his fellows in England, and yet by this Bill it was proposed to establish an erroneous principle, in order to "stimulate invention," as it was called, upon the hypothesis that an inventor must be twenty-one years a-head of everybody else. In fact, the basis of the Patent-laws was the picking out of individuals who might possess audacity, but be devoid of real merit. It was not always the most meritorious man who ran off first to the Patent-office, and the talk about "stimulating invention by means of letters patent" was really an abuse of language, because it could not be done. To take the analogous case of the Victoria Cross, granted as a reward for valour in the field; experienced officers would tell them that it simply conduced to the neglect of the sober, steady duties of camp life, in order that men might show off. Invention could not be stimulated, because the public mind was always at work. He could point to men, in support of his statement, who could invent almost anything to order. However, the Bill was admirable since it continued the old chaotic system of unpaid Commissioners, for the appointment of paid Commissioners would be nothing less than a farce, unless competent skilled persons were appointed to act as a sort of sub-committee to examine inventions. The only instance of real justice done by the Bill was in Clause 19, which provided that the privileges granted to patentees were to be subject to the revision of the Lord Chancellor, in order that he might take care, according to the circumstances, that the interests of other parties equally engaged with patentees in the prosecution of manufacturing industries might be protested. As the committee upon the existing system of Patent-law had said, care should be taken, while stimulating invention, that existing interests should be guarded, and Clause 19 would, at least, do that justice.

The Chairman reminded the meeting that the discussion was upon the Government Patent Bill, and not upon the general question, whether Patent-laws should or not exist.

Mr. Sedgwick Woolley thought the key-note had been given to the discussion by Mr. Bramwell in his opening remarks, when he said that many people considered those protected by patents to be adversaries of the public at large. As competition was in trade a benefit to the community, so would competition in invention tend to the public benefit, by introducing cheaper goods, and they ought, therefore, to endeavour to make protection for inventors as easily to be obtained as possible, by reducing the cost of taking out patents. Artisans constantly employed upon machinery were a large class, who must continually perceive means by which existing machinery could be improved, and if these men had the means of obtaining protection in working out their ideas, the public would benefit by many inventions which were now abso-

lutely lost. Some three or four years ago a committee of Scotch inventors brought forward a suggestion that the payment on the filing of the first specification should be £5, on the sealing £5, and £3 or £4 a year afterwards. By such a reduction as that, even the revenue would not suffer loss, because an enormous increase would naturally then take place in the number of inventions patented. This Bill seemed rather to put difficulties in the way of patentees than to assist them, especially by the clause providing for the publication of the specifications before sealing, and for opposition before the law officer to be then allowed. As Mr. Wise had pointed out in his paper, opposition upon open documents meant simply law suits and nothing else, and as there was a further appeal to the Lord Chancellor, it was simply a hopeless case for inventors in the position of poor artisans to attempt to get their patents sealed, because manufacturers, reluctant to go to the expense of new plant and rival patentees, wishing to prevent their own inventions being knocked on the head, would simply squash invention entirely. Any deputation from the Society should certainly press the point of prior publication. It had been stated that there was an absence of provision for examination in the Bill, but Clause 43 provided for it; at all events, as Government had been so prone to the idea of appointing examiners, there was no guarantee that they would not bring in examiners afterwards, and some guarantee should be given against it. He objected to any examination at all, unless the examiners were infallible in every branch of science, and that, of course, was impossible. They would be sure to leave out something or other, at which inventors would grumble, and the public be dissatisfied, and the whole system of Patent-law would be brought into disrepute. Objection had been made that inventions would, without it, be patented twice over, but that might be left to work itself out under a reduced rate, because men would be inclined to drop patents which had been already taken out if they had only paid £5 upon them. The Patent-office might also give great assistance to patentees by affording increased facilities for search, and by establishing a good library, a system of indexes, and something like the American *Patent Gazette*, with a short treatise at the beginning of each subject, reference to all the books on the subject, and, if possible, a small engraving illustrating each patent, so that inventors might study the matter at their leisure, which would assist them more than any amount of examination which could be provided for. Again, it would be for the public benefit that old inventions, which had not been worked, should be dug up and put to use. He disapproved entirely of the system of providing models, on account of their expense, and the length of time required for their preparation.

Mr. Trueman Wood (the Secretary) said this Bill seemed to arouse less discussion than those which had preceded it, from the fact that they had been so bad that anybody with any knowledge of the subject could easily fling a stone at them, whereas this measure seemed so great an improvement that inventors and others interested would be inclined to let it pass. It could not pass, however, this year, but they might expect to get from Government next year one as much superior to this as this was to the Bill of 1877, and if so, it would be a very excellent Bill indeed. One great improvement in this Bill was the extension of the time allowed for the provisional specification, which was at present really too short. Other good points were the appeal from the law officer's decision, the liberty to amend without putting in a new specification, and the reduction in the earlier payments. The drawbacks in the Bill were more numerous, but they had been already pointed out. The question of opposition upon open documents had been much alluded to, but he could not see that by the Bill, as at present drafted, there would of necessity be such opposition. It provided that any person could within a "prescribed time" give notice of opposition, but that time was to be fixed by the Commissioners; and it might be fixed so as to admit of opposition being allowed after the publication of the specification or not. Indeed, it would depend entirely upon the rules and orders framed by the Commissioners how the Act was to be administered. That was the greatest blot in the Bill, as had been pointed out by Mr. Cowper. The Commissioners had not of late shown themselves very eager to protect the interest of patentees. Their chief object appeared to have been economy. Those familiar with the printed specifications knew the objectionable alterations which had been made in that respect, and the present drawings, instead of being plain and clear could not be seen unless under a microscope. The question of examination had been referred to by previous speakers. He had read a paper to the Society two years ago on the subject of examination, and had done his best to oppose the Bill then proposed. They ought to give the Government credit for not trying to introduce by a side wind what they had refrained from introducing legitimately, and there was no reason to suppose that anything like examination was intended. Careful reading of the Bill would no doubt show that power was placed in the hands of the Commissioners to appoint examiners or do anything else they liked, but there was no reason to suspect they would do so. Another point was that the Bill itself did not provide for unpaid Commissioners but only for Commissioners, though in the list of contents the word "unpaid" was used. The Bill merely said, "such five other persons as her Majesty shall appoint;" and that was a mere repetition of the Act of 1852, which had remained a mere dead letter down to the present time. However, he supposed they might take it the meaning of the Bill was that the Commissioners should be unpaid.

Mr. Lewis Olrick said that as a member of the Permanent Paris Patent Congress and the Patent Law Committee, he had had the opportunity of fully considering the different Bills which had been proposed, and thought it possible this measure might not be passed this year. It was their duty to state clearly and concisely to the Government, through the press, the points in it of which they approved and disapproved. Mr. Wise had stated so clearly why it was unadvisable to have unpaid Commissioners, that he should not say a word more on that point. With regard to the fees payable for patents, he was of opinion that the fees paid by inventors should not exceed the requirements for the maintenance of the Patent-office. He believed a payment of £5 a year would be sufficient, and was of opinion that it would ultimately come to that. That payment for 21 years would amount to 100 guineas, which, in addition to the fees of the patent agents, would be a fair and reasonable payment for the monopoly (though he did not like to use the word) granted to inventors. In comparing the American system with ours, it should be remembered that expensive models were there required, a useless provision, which he hoped would not be introduced into the English Patent-law. It should also be remembered that sometimes an English patent contained as many as 20 American patents, and, therefore, the cheapness of the American fees would often completely vanish. The publication of the complete specification was a point in the Bill which should be strongly condemned. No description of an invention, except the provisional specification, should be published before the granting of the patent, and that publication should not take place until after the filing of the complete specification. After the filing of the complete specification, and previous to its publication, the Patent-office should simply see that the patent complied with three requisitions; first, that the specification was clear; secondly, that it was not contrary to public morals; and, thirdly, that it was not wanting in novelty; the last point being decided solely by prior publication in the Patent-office itself. In no case whatever should a patent be refused

to an inventor unless it were against public morals, and the final specification should be published immediately after the granting of the patent. The proposed extension of the life of patents to 21 years was a great boon, but Government ought to go one step further, and extend it to patents in existence at the time the Bill should come into force. Clauses 16 and 17, with regard to extension of time, alterations, or amendments and additions to existing patents, were a great boon to inventors, who sometimes, by mistake, made slips of omission. In paragraph 18, Government had exercised sound judgment by proposing that the Crown should pay for the use of inventions like anybody else; but provision should have been also made for referring the question of amount of payment to an independent referee, for a Government official can not be considered as independent. Clause 19 was one of the most damaging parts of the Bill, as it dealt with revocations of patents, compulsory licensing, and compulsory working, and it was really a violent interference with the rights of property. On that point the Paris Congress had passed a resolution that patents should, throughout their whole term, give to the patentees or their assignees the exclusive right to the inventions, and not the mere right of receiving royalties from third parties. One of the arguments in favour of the proposition was that a man should not be allowed to act like the dog in the manger; but Mr. Aston, Q.C., with all his experience, had only known one case of the kind, and the matter might safely be left to the patentee, who is most interested in making a fair arrangement. The proposition for the Lord Chancellor stepping in to decide what should be paid for licenses, would never work, for though an eminent lawyer, he was without training in commercial pursuits and in business matters, which was necessary for the decision of such matters. He disapproved of the proposal that patents should cease to exist in England on the expiration of foreign patents previously taken out; but a clause should be inserted for the punishment of persons using the word "patent" when no patent had been taken out first, as it was virtually obtaining money under false pretences. He hoped the Attorney-General would find time to read this discussion, and thereby ascertain the opinions of independent practical men on the subject, and he felt confident that when it was thoroughly understood by Government and the House of Commons, that an inventor of a valuable invention was really one of the greatest benefactors to the public, the House would pass a Bill which would do justice alike to the inventor and to the public at large.

Admiral Selwyn rose to a point of order, and remarked that though it was customary for the mover of the adjournment to resume the discussion, he had not been afforded the opportunity of addressing the meeting.

The Chairman understood that Admiral Selwyn had spoken on the previous occasion.

Admiral Selwyn—Only for a very few minutes, as time would not admit of more.

Mr. Smartt suggested that the discussion should be again adjourned. The proposer of the last adjournment, who was as good an authority on the subject as any member present, should at least have been placed at the head of the list of speakers.

Mr. Cowper seconded the motion.

Mr. Alexander said as his intended remarks had been anticipated, he would simply state with Mr. Anderson, that he agreed with almost every word of Mr. Wise's able paper. One point, however, had not been touched upon. By Clause 33, power was given to the Lord Chancellor to refer patent petitions to a judge of the High Court, a very valuable and sensible provision, several of the judges being men possessing great scientific knowledge. They had, no doubt, much to congratulate themselves upon in the improvement shown in this Bill; and if they went on with this process of pointing out objectionable features to Government, and getting them eliminated year by year, they would at last arrive at the consolidation, with amendments, of the present Patent-law.

The Chairman said the subject was of great importance, and might with advantage be further discussed, but he was informed it would be impossible to appoint another date for the purpose.

Admiral Selwyn urged, as a very old member of the Society, that the matter should be pressed upon the Council, as the subject lay at the basis of the whole manufactures and commerce of the country.

The Chairman said that question would have to be brought before the Council, but the object of this discussion was to come to some practical conclusion.

Mr. Wise said if the meeting were adjourned he would attend and reply, and, if not, he would forward his reply to the *Journal.*

The Chairman then put the motion that the debate be adjourned to a day to be named by the Council.

The motion was carried, and the meeting adjourned.

TWENTY-SECOND ORDINARY MEETING.

Wednesday, May 21st, 1879; Professor JOHN TYNDALL, LL.D., D.C.L., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Blakesley, Thomas Holmes, M.A., 26, West Cromwell-road, S.W.
Bradford, Thomas, Crescent Iron Works, Salford, Manchester, and Springfield, Eccles, Manchester.
Croft, Henry, C.E., Aldeburgh, Suffolk.
Cowper, The Hon. Henry, M.P., 4, St. James's-square, S.W.
Hyde, Samuel, M.R.C.S., Buxton-house, Buxton.
Layton, Thomas, Kew-bridge, Kew.
Phillips, John W., 32, Lewisham High-road, S.E.
Phillips, W., 25, Coal-exchange, E.C.
Salmon, R. H., Caterham Court, Surrey.
Skrine, Henry Duncan, Warleigh Manor, Bath.
Walter, John, M.P., 40, Upper Grosvenor-street, W.

The following candidates were balloted for and duly elected members of the Society:—

Best, Frederick A., Church-hill, Walthamstow, E.
Corbett, Joseph, 24, Barton-arcade, Manchester.
Cutlers, The Master of the Worshipful Company of, Cutlers'-hall, Cloak-lane, E.C.
Flynt, William Garnett, Southport, Lancashire.
Freeman, William, 2, Lorne-villas, Brockley-road, Forest-hill, S.E.
Griffith, Edward F., 18, Abingdon-street, S.W.
Gentles, Thomas Lawrie, Wellington-house, Derby.
Kemp, Charles, Southerton, Ottery St. Mary, Devon.
Le Grand, Alfred, Magdala Works, Bunhill-row, E.C.
Lloyd, Thomas, Winchester, Hants.
Newton, George Robert, Heckington, Lincolnshire.
Ormsby, Arthur Sydney, 11, Kildare-gardens, Bayswater, W., and Scientific Club, Savile-row, W.
Phillips, John, 13, Gayton-crescent, Hampstead, N.W.
Yuill, W., 3, Fenchurch-avenue, E.C.

The paper read was—

ON EDISON'S ELECTRO-CHEMICAL OR LOUD-SPEAKING TELEPHONE.

By Conrad W. Cooke, C.E.,

Member of the Society of Telegraph Engineers.

The first public announcement in this country of the successful transmission of articulate speech to a distance, by means of electricity, was made by Sir William Thomson, in his opening address to the Mathematical and Physical Section of the British Association, at the meeting which was held in the City of Glasgow in the year 1876. In that address occur the following memorable words, which will ever be associated with the early history of telephonic science:—

"I heard the words, 'To be, or not to be. . . . there's the rub," through an electric telegraph wire. . . . This, my own ears heard, spoken to me with unmistakeable distinctness, by the thin, circular disc armature of just such another little electro-magnet as this which I hold in my hand. The words were shouted with a clear and loud voice by my colleague-judge, Professor Watson, at the far end of the telegraph wire, holding his mouth close to a stretched membrane, such as you see before you here, carrying a little piece of soft iron, which was thus made to perform, in the neighbourhood of an electro-magnet in circuit with the line, motions proportional to the sonorific motions of the air. This, the greatest, by far, of all the marvels of the electric telegraph, is due to a young countryman of our own, Mr. Graham Bell, of Edinburgh, and Montreal, and Boston, now becoming a naturalised citizen of the United States. Who can but admire the hardihood of invention which devised such very slight means to realise the mathematical conception that, if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously, and as nearly as may be, in simple proportion to the velocity of a particle of air engaged in constituting the sound."

With these words was introdueed to this country an invention, which within two years was destined to find an enormous and world-wide application, and which was the first of that marvellous series of developments in physical science which have lately succeeded one another so rapidly, that it is well nigh impossible to keep count of their number or to estimate the scientific value of their results.

Long before "the hardihood of invention," however, had deemed it possible to transmit articulate speech to a distance, investigators had turned their attention to the means of transmitting musical notes electrically, as a practical and useful mode of telegraphing signals. Four names stand out prominently in connection with this branch of science—those of Reis, Varley, La Cour, and Elisha Gray. All of these experimenters followed the same principle by different ways. In all their systems a sounding body yielding a note was employed, the vibration of which serves to make and break contact, giving to a current of electricity an intermittent character, the number of interruptions varying of course with the note sounded at the transmitting end; and the armature of an electro-magnet at the receiving station adjusted to respond to those impulses was arranged to communicate to the air the number of vibrations transmitted, and to reconvert them into sound.

REIS'S TELEPHONE.

In the year 1860, Philipp Reis constructed the first of this class of telephone. For his transmitter he employed a conical tube, the smaller end of which was closed by a delicate membrane. Against the centre of this rested the extremity of a light lever, supported at about the middle of its length, and perfectly free to vibrate. The upper end of this lever was kept in contact, when the apparatus was not at work, with a stud connected with one electrode of the battery, and when the membrane was thrown into vibration by sounding a musical note into the mouthpiece, its motion was communicated to the lever, and by its means contact was made and broken at each vibration. The receiving instrument consisted of an electro-magnet, joined up in the circuit of the line from the transmitting station, and placed on a sounding box. An armature, carrying above it a broad, thin plate, faced the poles of the magnet, and was lightly suspended on a light frame. When the instrument was operated, the intermittent current transmitted by the vibrating contact breaker at the transmitting end traversed the coils of the electro-magnet at the receiving end, and the armature with the plate attached was thereby set into corresponding vibration, and thus repeated the note which was sounded into the transmitter.

In the following year, that is to say, in the year 1861, Reis produced his second instrument, an illustration of which we will now throw upon the screen. From this illustration, you will see that the instrument is in two parts—a transmitter, which is figured at the top (its details being shown in the middle figure), and a receiving instrument, shown below. The transmitter consists essentially of a membrane stretched over a circular hole at the top of a cubical box, in front of which, and opening into it, is a mouthpiece. The membrane vibrating in unison with the impulses it receives from musical sounds played near it, transforms those impulses into a series of electrical currents by a simple make-and-break arrangement, and these currents acting on the receiving instrument, which may be hundreds of miles distant, reproduce the corresponding notes, so that a tune played at one station can be distinctly heard at the other.

Reis's receiving instrument is founded upon the well-known phenomenon discovered by Page in the year 1837, that a distinct sound accompanies the demagnetisation of an iron bar placed in an electro-magnetic helix. It consists of a soft iron bar about the size of a knitting needle, surrounded by a helix of wire, which forms part of a voltaic circuit with the transmitting instrument; and, for intensifying the effect, both instruments are provided with sounding boards or resonators.

When notes are sounded into the mouthpiece, the membrane is thrown into vibration, and a platinum plate, attached to its centre, makes and breaks contact with a contact screw, and in so doing completes and interrupts an electric current which traverses the receiving instrument, the bar of which becomes magnetised and demagnetised at each complete vibration. By this means, the note sounded into the transmitter is reproduced by the receiver, the action of the two instruments being isochronous.

The amplitude of vibration of the membrane is too small to be seen, except by one person at a time. I have here, however, a means devised by Mr.

Henry Edmunds, by which, I think, the various speeds of vibration due to different notes may be made apparent to everybody in the room. By placing this Reis transmitter in the primary current of an induction coil, I obtain a flash of light through the tube every time that the current is interrupted, and by causing the tube to rotate at a high velocity, a different figure will be produced for each note sounded into the transmitter.

[This experiment was shown, and each of the different notes sounded into the transmitter produced a different luminous figure.]

Varley's Telephone.

One of the earliest of the musical telephones was that devised by Mr. Cromwell Varley, in the year 1870. In that apparatus a tuning-fork or vibrating reed, in conjunction with an electrical condenser, was caused to transmit vibratory currents of electricity to a distant station, and there to reproduce musical sounds. It may be remembered that, a few months ago, a telephone on Mr. Varley's principle was exhibited in London, being established between the Queen's Theatre and another place of entertainment about two miles off.

La Cour's Telephone.

La Cour followed close upon Varley. His first experiments were made at Copenhagen, in June, 1874, at first on a short line, and afterwards over a length of about 250 miles. His apparatus was extremely simple. Like Varley, he employed a tuning-fork to reproduce the interruption in the current. This fork was placed horizontally, with its stem projecting through a wooden stand, and connected through a signalling key with the sending battery. A light spring, bearing with a pressure that can be adjusted upon one prong of the fork, was connected to the line. This instrument was worked by the signalling key in the ordinary manner, but the passing current was interrupted at each vibration of the fork, when it breaks contact with the light spring before mentioned. The receiving instrument consisted of a soft iron fork, the prongs of which were surrounded (but free to vibrate) by bobbins wound with insulated wire. Close to the projecting ends of the fork were two vertical electro-magnets. The currents from the transmitting line passed through the coils around the fork, and thence through the other pair of electro-magnets. By this arrangement the prongs of the fork acquired polarity opposite to that of the electro-magnets, and were thrown into vibration at a rate depending upon the number of interruptions in the transmitted current; and a note, the counterpart of that transmitted, was the result.

Gray's Telephone.

In 1874, Elisha Gray invented a far more perfect telephone, in which a tuning fork or vibrating reed combined both functions of sound producer and contact breaker, as in Varley's and La Cour's instruments. When once adjusted, it only transmits to the receiving instrument the number of pulsations of current per second due to its own note. The receiver, like that of Reis, is formed of a horseshoe magnet, with a heavy armature attached to its poles, and mounted on a resonating board. A key-board like that of a harmonium forms a part of the transmitting instrument, which may be made to consist of any convenient number of musical contact breakers. It is on this principle that Dr. Gray has constructed his telephonic telegraph, in which four or more different messages may be transmitted simultaneously through the same wire. In this instrument there is a vibrator at the receiving station, tuned so as to be affected only by its corresponding transmitter at the other station; and, by employing intermediate receivers along a wire of different notes, the signals belonging to each are automatically transmitted, and the others are allowed to pass.

All these instruments, ingenious as they were, were, however, powerless to transmit the complicated vibrations of sound which go to make up articulate speech. Something more was required for the solution of this problem than for the conveying of simple musical notes.

Time does not permit me on this occasion to attempt more then a hurried sketch of the rise and development of telephonic telegraphy, which is, moreover, somewhat outside the subject which I have the honour of bringing before you this evening, that of the electrical transmission of articulate speech to a distance; and here I would say a few words on the general principles which control all the instruments of this class. It is scarcely necessary to remind you that all sounds, whether musical notes, articulate speech, or irregular noises, are produced by the movement of particles of air forming sound waves, thrown into motion by the vibration of the body, from which the sound emanates. These waves travel onwards till they strike the tympanum or membrane of the ear, the sympathetic vibrations of which, acting through the auditory nerves, convey to the brain the sensation which is known as hearing. The three characteristic features of a sound, namely, pitch, force, and quality, depend upon the dimensions and form of the sound waves propagated by it. The dimensions of a wave are (1) length determined by the number of vibrations propagated per unit of time, and it is this which determines the pitch of the sound; and (2) amplitude, *i.e.*, the depth of a wave measured from "crest" to "trough," which gives to a sound its force or loudness. The form or shape of the wave is the path traced out by its progressive motion among the particles of air in which it is propagated, and may have infinite variations, and it is this feature of sonorous vibrations that gives to a sound its quality, by which all the complex variations of articulate speech, as well as differences of voice, are communicated to the ear. No illustration of the existence and power of these sound waves is so striking as that afforded by the phonograph of Mr. Edison. In this instrument the sympathetic vibrations of a diaphragm produced by sounds striking upon it are made to record their characteristic features on a sheet of tin-foil, which is made to travel beneath a style attached to its centre, and which bears against the unsupported surface of the foil; and, as you know, so perfectly are the sound waves imprinted upon it, that, when the operation is reversed, and the foil is again traversed beneath the style, the latter, finding its way into all the nooks and recesses of the imprinted record (treading, so to speak, in its own footprints), throws the diaphragm again into vibration, reproducing thereby, or rather repeating, the sounds, whether

articulate or otherwise, by which the imprinted record was in the first instance produced. It is this astonishing power possessed by sonorous vibrations of imparting, to a suitable diaphragm, movements possessing all their own characteristics, and containing, within the almost infinitesimal range of their vibration, the vast varieties of form and of amplitude required to reproduce articulate speech.

The Thread Telephone.

The thread telephone, the simplest of all, will serve to illustrate the mechanical transmission of sonorous vibrations. This instrument, of which I have an illustrative diagram on the wall, consists simply of a transmitting and receiving box, the end of each of which is closed by a stretched membrane, and the two membranes or diaphragms are connected together by a thread or wire attached to the centre. Through this connecting thread the motion of the one membrane is communicated to the other, and sound waves may in this way be conveyed, to a considerable distance, and be reproduced audibly on the membrane at the other end. Mr. J. W. Millar has carried out a series of very interesting and valuable experiments on the transmission of sound by this means, and these experiments formed the subject of a paper read by that gentleman before the Physical Society.* Mr. Millar found it easy to transmit minute and delicate sounds through a distance of 150 yards through a No. 26 copper wire, that is to say, a wire ·018 of an inch in diameter. To each end of the wire was attached a sheet-iron disc 3½ inches diameter, fastened into a wooden rim about half an inch deep. With this primitive arrangement, breathing, whistling, singing, the sound emitted by a tuning-fork, and articulate speech were freely transmitted. At shorter distances, words and sounds not spoken on the disc, but at one side of it, were clearly rendered, and it is remarkable that the sound was but little, if at all, interfered with when the wire lay upon the ground, or was in contact at short intervals with points of support. The diagram before you will illustrate fully the action of this class of telephone, and I think it will be clear that if delicate sounds have of themselves sufficient power to set up so great a mechanical action in a sheet of metal through a long length of wire, far more perfect and useful results may be expected if the sound waves be confined only to the vibration of the diaphragm, and another agent, such as electricity, be employed to transmit the message through the wire.

Bell's Telephone.

In the summer of 1876, Prof. Graham Bell exhibited at the Centennial Exhibition of Philadelphia, to a favoured few, his articulating telephone, which elicited from Sir William Thomson the expressions of admiration which I quoted at the commencement of this paper. The form of the transmitting instrument is that which I now show you: it consists of a horizontal electro-magnet, in front of which and perpendicular to the plane of its axis, is fixed a brass ring, over which a membrane is stretched, and which can be tightened like a drum by means of the mill-headed screws shown; to the centre of this membrane is attached a small oblong piece of iron, situated immediately in front of, and almost in contact with, the poles of the electro-magnet; the binding-screws on the stand of the instrument are used to place the coils in circuit with the receiving instrument, an illustration of which I now throw upon the screen. This was formed of a thick tube of soft iron, enclosing a vertical bar electro-magnet, rather shorter in length than itself, the two being so connected at the lower end that, while the central bar under the influence of the current assumed north magnetic polarity, the tube surrounding it became by induction a south pole of annular form. To the top of this tube was fastened, by a small screw, an iron disc about the thickness of cartridge-paper, and this disc, under the influence of a voltaic current, was held firmly down by the annular pole, its centre being in front of the shorter central pole. It thus constituted a diaphragm held by its edge by magnetic attraction, its centre being presented to the north pole of a magnet as in the later receiver. The action of the instrument may be explained as follows:—When sound waves are projected against the membrane of the transmitting instrument, the iron strip attached to it is set in motion in the manner I have already described, and plays to and fro in front of the poles of the electro-magnet in obedience to the impulses of the sonorous vibrations; by this action a series of variations in the strength of the currents are induced, proportional to and synchronous with the variations in the movement of the membranes, and these variations are transmitted by the connecting wire to the receiving instrument, and are reproduced there and converted into sonorous vibrations by means of the diaphragm armature of the receiving instrument.

Although three years have not elapsed since Bell first showed his earliest form of telephone, the principle he then discovered has been eagerly seized by a number of other investigators, and many telephones, more or less perfect in their action, have been given to the world in that short interval. Time will not permit me to do more than indicate very briefly the arrangement of those instruments possessing practical value, especially as the latest and most beautiful form which I shall have to bring under your notice, the loud-speaking telephone of Mr. Edison, must occupy a considerable portion of this paper.

The two lower figures in the diagram before you illustrate the present form of the Bell telephone; it consists of a neat wooden case (in America these cases are made of ebonite, and are remarkable for their form and finish). In the centre of this case is the magnet, a cylindrical steel bar, five inches long and three-eighths of an inch in diameter. At the front end is placed an ebonite bobbin carrying the coil, the ends of which are soldered to two stout pieces of copper wire, which traverse the case and terminate in two binding screws at the rear end. The diaphragm in front of the magnet is held in place by the mouth-piece, which is screwed down to the body of the case; the opening left in the mouth-piece being about half an inch in diameter. The action of this instrument is precisely similar to that of the transmitter last described. The results obtained with this instrument, though feeble, have been very remarkable. In the early days of its existence,

* "On the Transmission of Vocal and Other Sounds by Wires," read before the Physical Society, 1878.

conversation could be freely carried on between Boston and New York, by means of a telegraph wire 258 miles in length, breathing was distinctly heard at a distance of 150 miles, and some very interesting and successful experiments have been carried out on the submarine cable between Dover and Calais. But in these experiments the weak point of telephonic transmission was very strikingly manifested. The wire through which conversation was successfully carried on was one of four forming the cable, the other three being in regular use for telegraphic purposes at the time; the currents induced by those passing through these three wires made themselves audible, like an electric echo as it were, so clearly and distinctly that the passing Morse signals could all be heard, and the flying messages deciphered and read as they passed through the wires; but this interfered with and partially drowned the delicate telephonic signal, and this difficulty is one which has interfered seriously with the adoption of the telephone in this country. I may mention that Mr. Edison has lately devised a means of protecting telephone circuits from these inductive influences.

Professor Bell's patent specification for the speaking telephone was filed in the United States Patent-office, on the 14th February, 1876, and it is a most remarkable illustration of the fact, that investigators, following the same line of inquiry, often arrive at similar results at the same time; for Elisha Gray's patent for the transmission of local sounds telegraphically, was filed at the United States Patent-office on the same day.

GOWER'S TELEPHONE.

A very great improvement has quite recently been made by Mr. F. A. Gower in the Bell telephone, by which not only is its clearness of articulation increased, but its power is augmented. With this instrument, an illustration of which we will now throw on the screen, it is possible to send messages without placing the mouth against the transmitter or the ear against the receiver, and it must be regarded as the most perfect modification of the Bell telephone yet introduced. It differs from that instrument only in the form and disposition of its parts. The magnet is a thick D-shaped bar of steel of rectangular cross section, carrying at its poles two flat pole-pieces of soft iron surrounded by flat coils of insulated wire. By this form, greater magnetic intensity is insured, and the two poles can be brought very close together, so as to be presented as nearly as possible to the centre of the diaphragm. A special feature of this telephone is the call or signalling apparatus, which consists of a musical reed of steel attached to the diaphragm, and vibrating in a slit cut therein. This reed is thrown into vibration by a puff of air blown into the speaking tube attached to the case, and, as its motion is wholly within the magnetic field, it transmits a synchronously vibrating current through the line wire, and the telephone at the distant station emits the same note. The method of using this instrument is exactly the same as persons are already accustomed to in the ordinary speaking tubes. The signal is given by blowing into the mouthpiece, and the messages are both transmitted and received through an ordinary speaking-tube mouthpiece and flexible tube. This point of resemblance is certainly in its favour, as it introduces nothing but what persons are accustomed to use.

GRAY'S LIQUID TELEPHONE.

The next diagram represents Dr. Gray's transmitting instrument, which consists of a cylindrical box, closed at the bottom with a membranous diaphragm, to the centre of which is attached a light rod passing nearly to the bottom of an insulated vessel beneath, the end of the rod being almost, but not quite, in contact with a conductor passing through the bottom of the insulated vessel. This vessel is filled with water, or some other fluid possessing a high degree of resistance. The receiving instrument consists of an ordinary electro-magnet, the poles of which are placed opposite to, and in close proximity to a piece of soft iron fixed to the centre of a membrane stretched across the bottom of a resonator. These two instruments are placed in circuit with the battery, the currents of which are controlled by the vibrations set up in the diaphragm of the transmitting instrument by sound waves striking upon it.

GRAY'S ELECTRO-MAGNETIC RECEIVER.

This diagram represents a more recent form of telephone devised by Professor Gray, and manufactured for general use by the Western Electric Telegraph Company of Chicago. As you will perceive, its arrangement is very simple. It consists of a soft iron handle, to the front of which is attached a soft iron bar, the upper end of which is fastened by a screw to the body of the instrument. The upper end of the handle carries a core, around which are two coils. The one to the rear is a polarising coil, and is connected to a battery, by which it is rendered magnetic, possessing opposite polarity to that of the diaphragm. The smaller core in front is connected to the line, in which another and similar instrument is in circuit. The regulator is simply a fine screw, by turning which, the soft iron bar, which always tends to approach the diaphragm, can be farther from or closer to it, as the adjustment may require. I understand Mr. Edison has also designed an instrument somewhat smaller in principle.

EDISON'S CARBON TELEPHONE.

It may be readily imagined that Mr. Edison turned his attention early to this field of inquiry, and following, at first, in the footsteps of Reis, he quickly diverged upon a new line of investigation, which terminated in the perfection of the carbon telephone. In this instrument, Mr. Edison made use of the well-known property possessed by some imperfect conductors of varying their resistance with variations of pressure, and the instrument first completed is shown in the diagram now thrown upon the screen. The general form of the instrument somewhat resembles the hand-telephone of Professor Graham Bell, although, of course, all analogy ends at this point. Through the middle of the body of the case passes a stem, terminating at its upper extremity in a shallow cylindrical box or cup; this stem can be raised or lowered by means of the adjusting screw at the lower end of the case; the cup just referred to contains, first, a thin platinum disc; second,

superimposed upon it, a button of carbon; and third, a second disc of platinum. This series is held in place by an annular cover screwed down on the box, and a thin iron diaphragm is employed, as in the Bell telephone, being held in place by the mouthpiece, which is screwed down upon it, a small piece of rubber-tube being introduced between the diaphragm and the upper platinum disc in such a manner as to exert a constant, but light, pressure upon the latter. The upper and lower discs of platinum are connected respectively to the two terminal screws, by which the instrument is placed in circuit with the battery and receiving instrument at the other end of the line. The action of this beautiful instrument depends upon the varying resistance of the carbon disc, due to variations of pressure exerted upon it by the movement of the diaphragm, under the influence of sonorous vibrations impinging upon it.

And here I would digress for a moment, to allude to two very interesting instruments closely allied in principle to the carbon telephone. The first is Mr. Edison's carbon rheostat, which is an instrument for varying the resistance of a circuit; it consists of a hollow vulcanite cylinder, partly filled with a large number of discs of silk that have previously been saturated with size, and well filled with fine plumbago; these discs are surmounted by a pressure block, which can be raised or lowered to any extent by a micrometer screw, and the resistance be thus varied at pleasure. The second instrument is the celebrated micro-tasimeter of Mr. Edison; this is shown also by a diagram. It consists of two heavy blocks, and cast in one piece with the base-plate. Upon the face of the block a vulcanite disc is secured by a platinum-headed screw, the head of which rests in the circular recess formed in the disc. In contact with this platinum head is a carbon button, and a disc of platinum is placed outside it and kept in position by the stud, the centre of which is recessed, to hold one end of a bar of any material the expansibility of which it is desired to test; the other end of this bar is supported in a similar manner by a bearing, placed at the end of an adjustable screw. The platinum discs are in circuit with the battery and a galvanometer, and so delicate is this instrument to variations of mechanical pressure, that if a strip of gelatine be placed between the supporting points, and a piece of moistened paper be brought within a few inches of it, the expansion arising therefrom, by increasing the pressure on the carbon, is instantly recorded in the galvanometer. The diagram on the screen shows the latest form of this marvellous instrument. In it a conical reflector is employed to concentrate the effects of variations in temperature upon the strip which is held between the clamp and the carbon and platinum discs, which are placed in circuit as before with a battery and galvanometer. The screw adjustment shown is employed for measuring exactly the degree of expansion produced. This is effected by noting the deflection produced in the galvanometer during an observation, and then by turning the screw until the same amount of deflection is obtained by direct pressure. The result will then be recorded on a dial. So delicate is this exquisite instrument, that by placing the hand in a line with the cone, and 30 feet distant from it, the action of the heat is instantly recorded by the galvanometer.

Edison's Moist Paper Telephone.

In 1877, Mr. Edison devised an instrument, of which a diagram is shown, in which the carbon button is replaced by a strip of bibulous paper moistened with water, and which possesses the property of changing its resistance under variation of pressure; the bottom of this instrument forms a water-chamber, in which one end of the paper-strip is immersed, the other end lies between two platinum discs placed in circuit with the battery; the arrangement of diaphragm, rubber contact-piece, being precisely like those described for the carbon telephone.

Edison's New Carbon Transmitter.

The latest form of Mr. Edison's carbon transmitter is that shown to the left of the diagram. In this, the carbon disc is contained within an ebonite ring, screwed to the metallic portion of the frame forming one of the connections of the circuit, and the carbon button rests upon this metallic surface. The other face of the button is covered with a disc of platinum foil, connected to an insulated terminal, and forming the other circuit connection, this foil is cemented to a disc of glass, in the centre of which is placed an aluminium stud that bears against the diaphragm of the instrument. This is an exceedingly simple and compact form of telephone.

The Crown Telephone.

The so-called crown telephone, devised by Mr. G. M. Phelps, of the Western Union Telegraph Company, has been used with excellent results in combination with the Edison carbon transmitter, although as a transmitting instrument it produces admirable results, and is an instrument of high merit. It consists of an ordinary combination of diaphragm, bar magnet and coil, but, in addition, there is a group of six permanent magnets, bent into a circular form, and having their similar poles joined up to the central bar carrying the coil. The other ends of these magnets are attached to the edge of the diaphragm.

Double Crown Telephone.

The double crown instrument shown in the diagram is simply a duplication of the radial group of magnets just described, a pair of coils also being introduced. These coils are so connected, that the currents generated by the vibrations of the discs are mutually strengthened.

Phelps' Telephone.

Another form of the Phelps' telephone includes a permanent bar magnet bent so that the poles are brought near to each other; attached to brackets on the poles of this magnet are two coils, opposite which are two diaphragms, and between them is a central mouthpiece opening into a chamber, in which the pulsations of the air in talking act upon the diaphragm through lateral openings. The coils are connected together so that the currents generated by the vibrations of the diaphragm are in the same direction when united, and are consequently much stronger than when only one coil is employed.

A similar instrument receives the message at the other end of the line. This is another form of Phelps' instrument largely made by the American Telephone Company. It consists of a mouthpiece placed at the upper part of an oval ebonite case containing a bent magnet connected to the bar carrying the coil behind the diaphragm, the other pole being attached to the periphery of the diaphragm in the same manner as are the bar magnets in the crown telephone just referred to.

TELEPHONIC PHENOMENA.

I have not nearly exhausted the history of the subject, nor must I attempt to do so; but I will trespass upon your patience so far as to refer to a few telephonic phenomena, and also to notice the practical application of the instrument in the United States. On these points, Mr. Prescott's work* is my authority. In August and September, 1877, five telephonic concerts were given in New York through some Edison transmitters, the music being distributed to several cities. The performances do not appear to have been remarkable for their success. But it is an interesting fact that the whole of these concerts were heard on distinct telephone circuits, at Providence, Rhode Island, and Albany, in the State of New York, neither of which places were in direct communication with the source of the sound. On investigation it was found that this effect was produced by induction, through at least three distinct lines, the effect not being diminished at the places where the music was originally transmitted.

Again, Professor E. W. Blake, utilising ten lines of rails for a telephone circuit, distinctly heard the Morse signals passing in the telegraph wires overhead. Lightning makes itself heard in the telephone, the sound being described as similar to that produced by pouring molten metal into water, or the hiss of a distant rocket, and what is curious is, that the sound is always heard before the flash is seen. Equally, the electrical disturbances accompanying the Aurora Borealis are also heard. Mr. Prescott gives another interesting example of the extreme delicacy of this instrument. He says that, in June, 1877, Professor Blake substituted, for the magnet of the telephone, a bar of soft iron, free from magnetism. When this was held in the line of the magnetic meridian the telephone worked readily by the induction from the earth's magnetism. At right angles to the line, it was absolutely silent, the sounds gradually dying away from the maximum as the first-named position was exchanged for the last.

With regard to the practical application of the telephone in the United States, I again derive some interesting details from Mr. Prescott's book. Within the last twelve months a mercantile telephonic exchange company has been organised in New York. The system includes a central station, connected by wires to each of the subscribers' offices, who can then communicate with each other by giving the signal to the attendant at the office to join up the necessary connections. All the wires of the system are brought together within a frame placed in the central bureau, and are led separately to different sections of a board on which the different combinations may be arranged. The sections are arranged side by side in two or more parallel rows, and within convenient reach of the operator. Each section is in connection with an alarm, and when a call is made from any of the stations, an indicator announces the number of the station, and the operator, ascertaining by inquiry with what other station the one signalling desires to be coupled up, the two wires are switched together, and the line is open for conversation. Automatic means are provided for informing the attendant when a communication is over, and the lines are free to be disconnected.

* "The Speaking Telephone, Electric Light, and other Recent Electrical Inventions," by George B. Prescott; New York, D. Appleton and Co.

BREGUET'S TELEPHONE.

Breguet's telephone merits more than a passing word. The transmitter and receiver are alike, and consist of a glass vessel containing mercury, over which floats some acidulated water. The pointed glass tube dipping into the vessel also contains mercury. These two vessels of mercury are connected, and over the top of each tube is a mouthpiece and diaphragm. On speaking above the tube of the transmitter, the vibrations are transmitted through the mercury, and contact is made with the acidulated water by means of the small opening left in the tube. The vibratory movements of the mercury by this means generate electro-capillary currents, which flow through to the receiving instrument, and reproduce the exact conditions which generate them, thus giving out the sounds spoken at the other end.

GRAY'S PHYSIOLOGICAL TELEPHONE.

One of the most original and extraordinary of all musical telephones is that which I have here, but which I am sorry not to be able to show you in action; it is the invention also of Elisha Gray, and is known as his physiological receiver. It is founded on a phenomenon first observed by Dr. Gray while watching some children playing with an induction coil, and giving one another shocks. He noticed that when a dry thin metallic surface, connected to one end of the secondary circuit of an induction coil, is rubbed by the hand, while the operator is holding the other end of the secondary wire, a sound is emitted by the hand at the point of contact with the metal, which sound has the same pitch and quality as that given out by the contact-breaker of the coil. Raising or lowering the speed of vibration of this contact-breaker immediately raised or lowered the pitch of the note, and from this he was led to construct a keyboard containing an octave of keys, each of which, on being depressed, started into vibration a reed, which, while giving out the note corresponding to its key, transmitted to the induction coil at the receiving end an intermittent current of electricity. With this transmitting instrument, he was enabled to cause the finger of his assistant at the other end to reproduce whatever tunes were played on the keyboard.

The instrument which I have before me is, I believe, the original apparatus used by Dr. Elisha Gray (for the loan I am indebted to Mr. W. H. Preece, C.E., the eminent electrician to the Post-office) for reproducing the sounds so transmitted. In using this instrument, the thin metal chamber is connected through the stand to one terminal of an induction coil, in circuit with the musical sound

transmitted at the distant station, and the operator, taking hold of a wire connected to the other terminal, presses his fingers on the metal surface while he turns the handle with the other hand. With this simple apparatus, every tune played at the transmitting end was reproduced, and it was found that the more rapid the rotation the louder was the sound, no sound whatever being emitted when the rotation was suspended. It was at first thought that the sound was produced by some physiological effect produced by the electrical current on the nerves and muscles of the hand, but Dr. Tyndall's experiments completely proved that the phenomenon could in no way be connected with nervous influence, for he obtained the same effects from dead animal tissue.

In connection with the subject of the present paper, it is a specially interesting fact that Dr. Gray found that the friction between the finger and the rotating cap was greater when the current was passing then it was when interrupted, and, moreover, that tho sonorous effects were entirely destroyed by the presence of moisture between the finger and the cap. These effects are the very reverse of those which obtain in Mr. Edison's electro-chemical telephone, and show, I think, very conclusively, that Dr. Gray's experiments were in no way connected with electrolysis. Dr. Gray explained it as an effect of electro-static attraction or repulsion. I am inclined, however, to think that the sounds must be attributed to a large number of minute electrical discharges taking place between the hand and the metal, which would be longer and more audible as the contact became more imperfect though more rapid rotation, and would cease altogether when, either by stopping the rotation or by allowing moisture to be present, that contact was rendered more perfect.

We now come to speak of a receiving instrument whose diaphragm is set into vibration by a process altogether different in principle to any that has been described. This is Mr. Edison's electro-chemical, or loud-speaking telephone, which I have the honour of bringing before your notice this evening, and which is certainly unrivalled for power, and is, in its perfected form, I think, equal, if it is not superior, to all other receivers for clearness of articulation. I can only hope that the experimental instrument which we have here to-night will, on this occasion, behave in as exemplary a manner as it did before the lecture, and as it has on every occasion when I have seen it before.

Before exhibiting the working of the instrument, it will be well to describe its principle of construction, for the phenomena brought into play by its action are of the highest scientific interest. About the year 1872, Mr. Edison made the discovery that if a strip of paper (see Fig. 1), moistened with a chemical solution that is readily decomposed when a current of electricity is passed through it be drawn over a metal plate connected with the positive pole of a voltaic battery and beneath a platinum style, bearing upon it with a gentle pressure, and which can be connected to the negative pole by means of a key or contact maker, whenever the current is allowed to pass, the friction is instantly reduced between the surface of the prepared paper and the platinum style, to be immediately restored the moment the current is again interrupted; from which it follows that if the paper be drawn with a uniform tractive force below the style, it will slip whenever an electrical current is transmitted through it, and will be retarded again by a frictional resistance the moment that the current ceases to flow

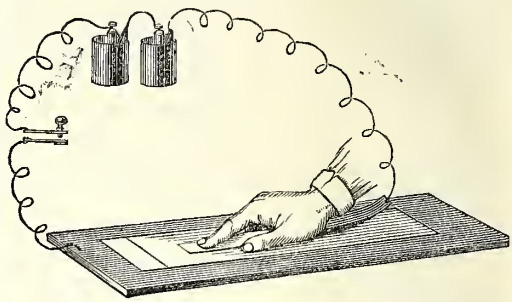


Fig. 1.

Here, then, was a new method of obtaining mechanical motion by the passage of a current of electricity, and Mr. Edison at once applied the principle to the construction of a telegraphic relay instrument, in which the employment of electro-magnets was entirely dispensed with. To this instrument Mr. Edison gave the name electro-motograph; and while a diagram view of the instrument is being thrown upon the screen, it may be well to mention that the object of a relay instrument is to translate feeble electric currents into strong ones. The recording instruments used in telegraphy require a certain strength of current in order to work them, and as the strength of an electric current diminishes as the length of the current is increased, it follows that in long distances of telegraphic communication a point is reached at which a current becomes so weak through the resistance interposed, that it is unable to work the heavy printing or recording instruments. The object of a relay instrument is to utilise this weak current for throwing into the circuit of the recorder a fresh local current of sufficient strength, in other words, being itself sensitive to the feeblest currents, it is capable, by its own mechanical movement, of throwing into circuit with the recording instrument to be worked a powerful local battery, thus becoming an automatic operator, and dispensing with the services of a translating clerk.

The Electro-Motograph.

In the diagram before you, a strip of chemically prepared paper is drawn at a uniform speed beneath a platinum point, by a roller rotating by means of clockwork. A platinum style is fixed to the end of a long lever, mounted upon a universal joint, and is connected to the negative pole of the line battery, which may be at a distant station. The movement of the paper, when no current is traversing the instrument is to drag the lever, by the friction between them, away from a contact screw. The moment, however, that a current of electricity is transmitted through the prepared paper, the friction between it and the style is instantly reduced, and the lever flies back against its contact screw, by the unopposed tension of a spiral spring. The effect of this is to throw into circuit with the recording instrument a local battery, by which it is

worked. The sensitiveness and rapidity of action of this instrument are something extraordinary, as it has been worked with complete success over circuits of two hundred miles in length, with the feeble electric current generated by two cells of a voltaic battery, as well as through resistances which would prevent an ordinary galvanometer from being affected by the current. And as the action is instantaneous, a far higher speed of working is insured by it than is possible with the use of electro-magnets, which occupy an appreciable time in becoming magnetised under the influence of a current, and in parting with their magnetism when that current is interrupted.

THE MUSICAL ELECTRO-MOTOGRAPH.

Through the kindness of my friend, Mr. W. H. Preece, I am enabled to show you the first form of telephonic receiver made by Mr. Edison, in which the principle of the electro-motograph is made use of. In this instrument a band of paper, moistened with a solution of sulphate of soda, is drawn between a platinum roller and a style of the same metal; the roller is connected with the copper terminal of a battery, and the style with the wire leading from the zinc, and a Reis transmitter is included in the circuit. On turning the small winch handle, the paper is drawn beneath the style, and considerable resistance is felt, due to the friction of the edge of the style on the paper; the moment, however, that the current is completed the friction is reduced, and the paper thus liberated makes a little start forward, giving to the sounding-board of the instrument a slight shake or tremor. Now, if, while turning the handle, we can transmit through the prepared paper a number of electrical impulses per second, corresponding to the number of vibrations constituting a musical note, the tremors communicated to the sounding board, through the slipping of the paper, will succeed one another at the same interval of time, and the resonating board will give out the corresponding note. Underneath the board are strung a number of wires, tuned to form a gamut, and by their means the notes given out by the instrument are reinforced by sympathetic vibration.

EDISON'S ELECTRO-CHEMICAL TELEPHONE.

Mr. Edison's loud speaking telephone depends for its action upon identically the same principle, and, in order to render this clear, I will ask for the explanatory diagram (Fig. 2) to be projected on the screen. A is a cylinder composed of precipitated chalk, to which a small proportion of acetate of mercury is added, the whole being moistened into a saturated solution of caustic potash and moulded into a cylindrical form by being subjected to hydraulic pressure. This cylinder is mounted upon a horizontal axis, B B, and is made by suitable mechanism to revolve beneath a metallic strip, C, which is maintained with a uniform pressure against the surface of the chalk. At the point where the strip, C, rests upon the cylinder, a small plate of platinum is fastened, and the opposite end of the strip is attached to the centre of a diaphragm of mica, D, four inches in diameter, firmly fixed to the framing of the instrument by its circumference. By connecting the strip, C, to the zinc element of a voltaic battery, and the chalk cylinder to the copper pole, and rotating the cylinder at a uniform speed away from the diaphragm, it will be found that, when no current is passing, the friction between the moistened surface of the chalk and the platinum strip is sufficient to drag the centre of the diaphragm inwards, and it will take up a fixed position of equilibrium when the frictional pull in the centre of the diaphragm is equal to the elastic tension of the strained diaphragm. The moment, however, that an electric current is allowed to pass between the strip and the cylinder, electro-chemical decomposition takes place, the friction between them is reduced, and the diaphragm, finding its elastic tension unopposed, flies back to a second position of equilibrium dependent upon similar conditions; and, if a variable or undulatory current of electricity be transmitted through the instrument, the diaphragm will be kept in continual motion by the constantly varying friction existing between the chalk and the platinum dragging the diaphragm in opposition to its own constant elastic tension. So marvellously sensitive is this simple mechanical arrangement to the smallest as well as to the most rapid and complicated variations in electrical intensity taking place in the transmitted current, that all the complex sonorous undulations propagated by human articulation instantly produce their corresponding variations of frictional resistance, and the diaphragm reproduces, in a loud voice, the words which are being uttered into the telephone at the distant station.

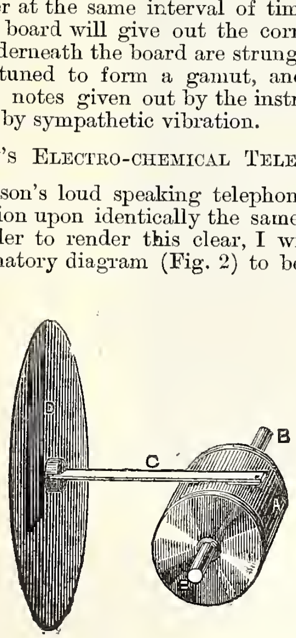


FIG. 2.

I have here a little apparatus which I have arranged to illustrate the electro-chemical principle upon which Mr. Edison's telephone works, and the process by which a current of electricity may be caused to produce mechanical motion by electro-chemical decomposition.

[In this experiment, a spot of light projected on a screen, was deflected some ten or twelve feet, the moment contact was made with a battery, by the depression of a key, the effect of which was to cause a mirror to move by the mechanical effect due to electro-chemical decomposition.]

The instrument which we have here this evening is merely a rough experimental apparatus for demonstrating the general principles of Mr. Edison's new telephone; it was hurriedly put together, in order to be sent to this country in time for illustrating a course of lectures on "Sound," recently delivered by our Chairman, Dr. Tyndall; and I am told that the whole apparatus was made, put together, and sent off within four days. It does

not, therefore, pretend to be either perfect or even reliable, but it has answered the purpose for which it was made admirably, and I hope it will do so again to-night.

The diagram before you (Fig. 3) represents a

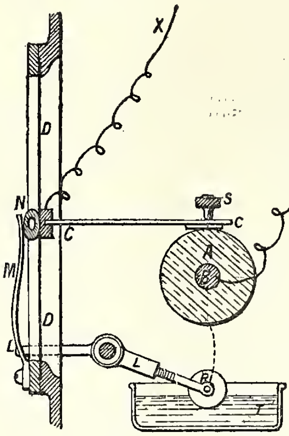


Fig. 3.

section taken through the instrument, showing the arrangement of the principal parts, and in the next illustration (Fig. 4) we have a view of the inside, as seen from the back. A is the chalk cylinder revolving on the spindle, B; D is the diaphragm, and W is the winch handle by which the cylinder is rotated. The general appearance of this apparatus is shown in the next diagram (Fig. 5), which we will have thrown upon the screen. And here I would mention, that the somewhat complicated appearance of this particular instrument, is due to the fact that it combines three instruments in one. The whole of the upper portion is the call-bell, or signalling apparatus, for calling attention between the two stations, and has nothing whatever to do with the working of the receiving instrument. Again, the funnel-shaped instrument projecting in front of the diaphragm is the transmitting carbon telephone, for speaking back to the other station. It was placed in that position for compactness and convenience; but it is not a good position, as it must interfere with the free propagation of sound waves into the room, by casting what may be called an accoustical shadow. In the perfected instruments, which, I believe, are now on their way from America, this arrangement is not repeated, the transmitter being mounted as a separate instrument.

I ought to mention here that in the perfected instruments, specimens of which will I hope shortly arrive in this country, motion will be communicated to the cylinder by a train of clockwork, which will be started and stopped by a simple electrical arrangement from the distant station. The new instruments will, therefore, not require turning by hand, and will be independent of all attention at the receiving station, with the exception of having occasionally to be wound up.

It has generally been observed that clearness of articulation in telephones is increased by working them on an induction circuit instead of with the direct current of the battery, and Mr. Edison has found that this is equally true of the instrument before us. He has, therefore, adopted the plan of placing the cylinder and strip in circuit with the

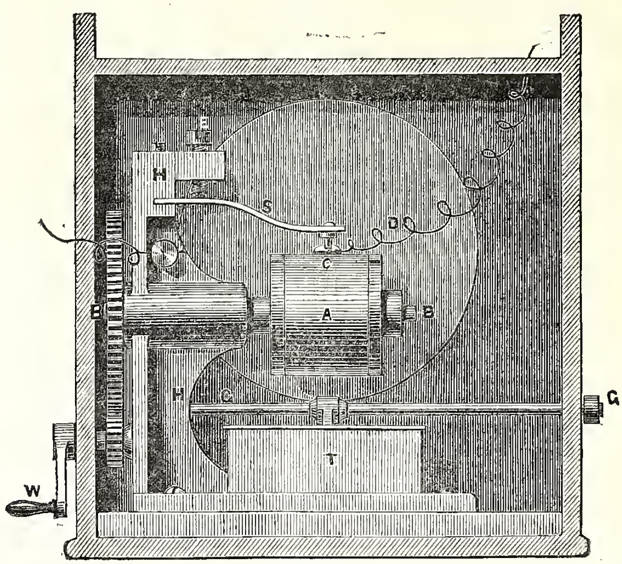


Fig. 4.

secondary wire of an induction coil, the transmitting telephone and battery being included in the primary circuit. The diagram (Fig. 6) which we will now throw upon the screen, shows the arrangement of the connections for a single pair of instruments. Here the receiving instrument is shown at R, its cylinder being connected to earth, and its platinum strip to the line which is joined to one end of secondary wire of the induction coil, C, the primary coil of which is placed in circuit with a

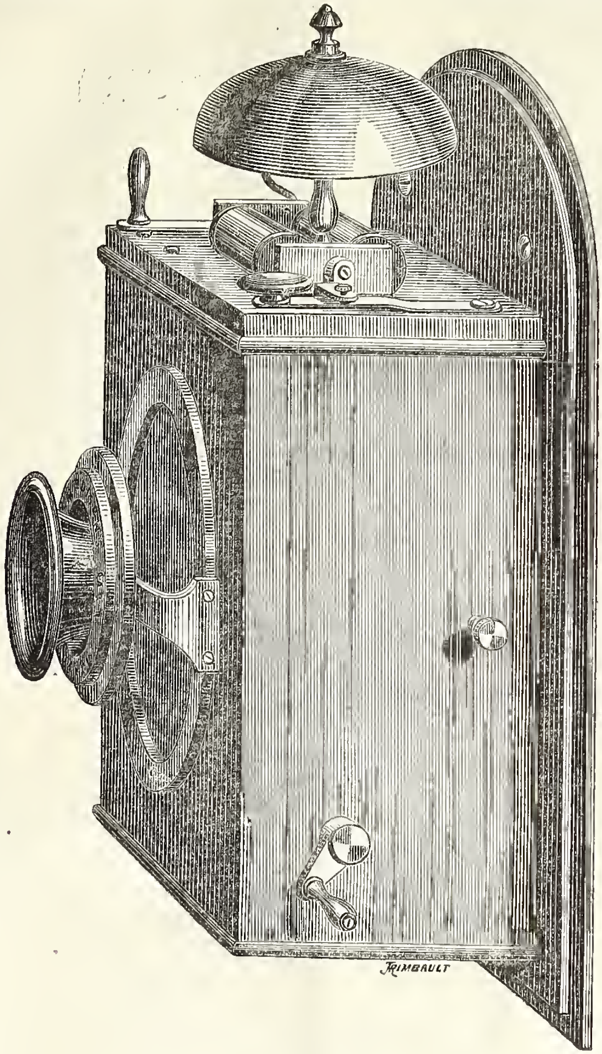


Fig. 5.

voltaic battery, B, and the carbon transmitter, T. The undulatory character which is imparted to the voltaic current by transmission through the carbon disc, whose resistance is continually varying under the influence of sonorous vibrations, produces by induction a corresponding undulatory current in the secondary circuit of the coil, and the current being transmitted by the line wire to the receiving instrument, by varying the degree of electro-chemical decomposition going on between the surface of the chalk and the platinum strip, causes a corresponding variation of the co-efficient of friction between the two surfaces, and the struggles of the diaphragm in its continual endeavour to establish equilibrium, under its own constant elastic force acting in one direction, and the varying frictional drag pulling in the other, make themselves apparent by reproducing the sounds by which the undulatory currents in the primary wire were originally produced.

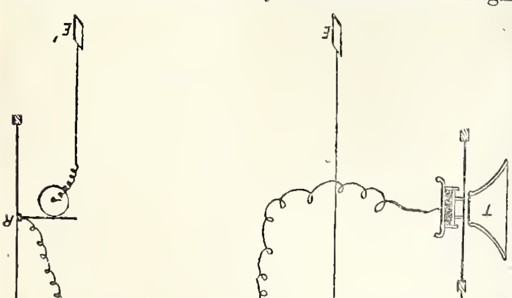


Fig. 6.

The instrument which you see fixed against the wall is now in communication with a distant part of the building, by a line thirty miles in length, and we will now send a signal to an

assistant at the other end, and ask him to speak to us through the telephone.

[Experiments were here made with the instrument; the words spoken and tunes sung, whistled, and played on the cornet, at the other end of the line, being distinctly heard in all parts of the room.]

The cause of the superiority in power of this instrument over others must be looked for in the fact that the vibration of the diaphragm is produced, not as in other telephones by an electric current, but by local mechanical means, that is to say, by the rotation of the cylinder by hand, by clock-work, or by any other motive power. The function of the electric current is purely a controlling and regulating one; it determines how much or how little of the force exerted on the spindle is to be communicated to the diaphragm, and the time when that force is to be brought into play, and it may, mechanically speaking, be compared to a frictional clutch, coupling a machine to a steam-engine, and which, at any moment, may be made to transmit the full power of the motor to the machine, or, by reducing the friction, to transmit only a portion of that power.

There is something exceedingly interesting in the *rationale* of this instrument, for it could never have been expected—I will go farther, and say it would not have been believed without experimental demonstration, that the almost infinite varieties of the sonorous vibrations constituting articulate speech could be reproduced by such processes as are called into action by this apparatus. It would have been expected that unevenness of surface, want of homogeneity of substance, irregularity of form or of speed, would each have left its mark upon the vibration of the diaphragm, and that innumerable disturbing causes and foreign sounds would have been introduced into its utterance, quite sufficient to have drowned all but the loudest and least delicate tones. But it is a curious fact, that neither unevenness of surface of the chalk cylinder, nor varieties of speed of its rotation, have any appreciable effect upon the sound produced. The cylinder we are using to-night is well-nigh worn out, and its surface is rough and uneven in the highest degree; and if I were to ask the gentleman at the other end of the line to sing a song to us, you would find that, however irregularly I might turn the handle, whether fast or slow, or first one and then the other, you would not be able to detect any difference in the sound omitted by the diaphragm.

[This experiment was tried, and the result was as indicated.]

The physical cause of the reduction of the co-efficient of friction must, I think, be looked for as an effect of electro-chemical decomposition. It may be, with some substance employed, due to the liberation of gas by the electrolysis at the negative end of the pole, which, in the instrument before us, is the platinum strip bearing on the impregnated cylinder. The sudden formation of a film of gas between the strip and the cylinder would perfectly account for the friction being reduced; and, again, even if gas be not liberated, a change in the chemical constitution of the chalk cylinder, at that point which is pressed by the platinum strip, would be accompanied by a change in the co-efficient of friction between them. To take an extreme and impossible case by way of illustration. Imagine the cylinder, instead of being made of chalk, to consist of a mixture of sand and soap, and suppose it were possible by some electro-chemical process to eliminate from the mixture, at the point pressed on by the strip, one or other of these two ingredients, an elimination of the soap would leave the sand, and an elimination of the sand would leave the soap. And according to the degree of elimination of one ingredient to hold the preparation of the other predominant, the result would be a variation of the co-efficient of friction between the cylinder and the strip, and the diaphragm would be more drawn towards the cylinder when its surface presented a sandy nature, to be relieved the moment that, by a variation of the process, it became more soapy. This is, of course, an altogether hypothetical case; but it serves to illustrate the inevitable change in the co-efficient of friction that must take place between two ruling bodies, if the chemical constitution of one of them be suddenly altered.

The perfect control, however, which an undulatory current of electricity exercises, through the process of electrolysis, upon the variation of the co-efficient of friction, must be a matter of astonishment to anyone acquainted with the extraordinary vagaries of friction, and nothing, I think, redounds more to the credit of Mr. Edison, who has given to the world so many novelties, than the utilisation of such a principle to produce such unexpected results. We may well, with respect to this, the last development of the articulating telephone, repeat what Sir William Thomson said of the first, "Who can but admire the hardihood of invention which devised such very slight means to realise the mathematical conception, that if electricity is to convey all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously, and as nearly as possible be in simple proportion to the velocity of a particle of air engaged in constituting the sound."

Inventions such as these bring very forcibly before the mind what must be evident to every person who watches the signs of the times, that the world is now passing through a period in its history especially characterised by its richness in scientific research in philosophical discovery, and in fertility of invention. The age in which we are living is essentially a scientific age, and an age of thirsting after scientific truth. Inventions and discoveries follow one another with such extraordinary rapidity, that there are persons who imagine that this onward march of scientific progress cannot continue much longer, that the end of discovery must in time be reached, and that all will have been found out that has to be discovered. In addressing such an assembly as the one I see before me, it would, on my part, be presumptuous, as well as superfluous, to refute so shallow a supposition, but I may be permitted to express my firm conviction that, as, throughout the whole of the world's history, each period has been richer in scientific discovery than any that have preceded it, so will this onward march of progress continue. Facts will go on being added to facts, inventions will follow inventions, and at a far more rapid rate during any one half century than in any of its predecessors, for every discovery

of science leads to a new group of inventions, and each invention repays the debt by rendering possible and facilitating the acquirement of fresh philosophical facts. The depths of nature are absolutely unfathomable; we may go on adding bit by bit to our sounding line, we may take out of her vast ocean bucketful after bucketful of the wealth with which she is stored, but we shall never reach the limit of her depth, or lower the level of her riches by a single inch.

It only remains for me now to perform the pleasurable duty of recording my sincere thanks to Mr. Arnold White, the representative of Mr. Edison in this country, for his very cordial co-operation, and for lending me the apparatus by which I have been enabled to demonstrate the working of the instrument; to Mr. W. H. Preece for the loan of the musical electro-motograph and the physiological receiver; to Professor Silvanus P. Thompson for most of the diagrams before you; and to my friends, Mr. Gimingham, Mr. Turney, and others who have so kindly assisted me this evening. I am indebted to the Editors of *Engineering* for a large number of the illustrations which I have been enabled to place before you, more especially to my friend Mr. James Dredge, for very substantial help which he has given me in the preparation of this paper; and, in conclusion, I beg to thank you, ladies and gentlemen, for the patience with which you have listened to what I have had to say.

DISCUSSION.

The Chairman said he was sure it was quite a work of supererogation on his part to ask the meeting to accord Mr. Cooke a vote of thanks for his most excellent paper. He had listened to it throughout with the very greatest interest, and had admired the grasp with which Mr. Cooke had managed to fasten on the whole subject from beginning to end. He had given its whole growth and development from its first inception to its final culmination. The audience must have felt more or less a strain on their attention, because a paper of this kind was really only a breaking of the ground; and he would recommend those who wished to get more profoundly into the subject to read it when published. Mr. Cooke had gone through the jungle and made a pathway through it to some extent, but they would have to travel over it afterwards if they wished to make it clear. It was only due to Mr. Edison to say that he was very desirous that they in England should be aware that this particular instrument was by no means perfect. That point had been emphasised by Mr. Cooke, but he would still farther strengthen the emphasis. The instrument had, in fact, been in action for a considerable time here; it had gone through a series of more or less rough trials, and when he had the honour of first operating with it, its tones were infinitely better than they had been that evening. Still, they had all heard them in a very clear and definite manner; but he would ask them to remember that the tones it was capable of producing were much better than those they had heard. He must take exception to one remark of Mr. Cooke's, when he said that a prima donna would hardly like to be interpreted by means of the telephone. He must ask them to observe that the imperfection in some of the upper notes of the musical illustration was not due to the instrument, but to the performer, and really showed the fidelity in which it reproduced the sounds. Mr. Cooke was the son of his eminent friend, Mr. E. W. Cooke, R.A., and if he had not the power of the artist, he had certainly associated with his paper a large amount of the power of the poet, in giving a visual conception of what he was speaking about. He was much struck by his expression with regard to the phonograph, saying that it trod in its own footsteps; nothing could be more characteristic of the action of the phonograph. He had struck the nail on the head, when he referred to what might and might not have been expected in regard to these revelations recently made. There was not a point which had been brought forward to-night from the beginning to the end of the development of the telephone, which if it had been placed before a scientific man, he would have said was impossible; but the dictum of the scientific man would infallibly have been—Mr. Graham Bell and Mr. Edison will never realise such a dream. It never could have been expected that these slight variations in resistance and in the strength of a current would produce the marvellous effects they had heard. It depended entirely on the experimental tact of skilful men taking advantage of the hints given by experiment. That was the line on which they had proceeded, and it had led them to these great results. One point struck him very much, and that was the curious manner in which these things occurred to the minds of men at the same time. So far back as the time of Newton, a great discovery occurred almost simultaneously to Newton himself and to Leibnitz; so in regard to the doctrine of the origin of species, it occurred almost simultaneously to Darwin and Wallace; and so with regard to another great generalisation, the conservation of energy, it occurred almost simultaneously to Meyer, Joule, and others; and the same thing was illustrated throughout the whole march of science. The general scientific thought of the age reached a certain level; the foremost pioneers were on that level, and at about the same time they reached the same results. With regard to the distance at which the sounds were heard, Mr. Cooke could only say that the sound was at the other end of the building, but when he (Dr. Tyndall) first made the experiment, the source of sound was at Piccadilly-circus, and the receiving instrument was in the Royal Institution in Albemarle-street; the sounds produced there were so clear and articulate that he repeated a poem of Emerson's, and every word of it was heard distinctly in the most distant part of the theatre.

The vote of thanks having been carried unanimously,

Mr. Cooke, in response, said his success was due in great part to the gentlemen who had assisted him in the experiments at the other end of the wires, and he would, therefore, transmit the vote to them through the telephone.

This was accordingly done, and a suitable reply received.

Lord Alfred Churchill then proposed a vote of thanks to Professor Tyndall for presiding, which brought the proceedings to a close.

Dr. Reuleaux is reported to have arranged, in London, for a space of 41,000 square feet, for the accommodation of the German Section at the Sydney Exhibition. England will occupy five times as much room, France half as much again, and Belgium about the same.

The Birmingham correspondent of the *Engineer* notes a steady growth in the demand which is being made upon the resources of the nickel plating establishments, both in Birmingham and Wolverhampton, and additional vats and more workmen are being generally set on. Iron and other metal wares complete are being nickel-plated extensively by firms who only recently adopted the method; and the favour in which the process is held as a means of ornamenting mountings for nearly every class of metal wares, is increasingly manifest.

THE STEAM "NAVVY."

By the invitation of Messrs. Lucas and Aird, some members of the Council, including Lord Alfred Churchill, Mr. E. Chadwick, C.B., Mr. Henry Doulton, Major Webber, R.E., and Mr. J. A. Youl, C.M.G., visited the works for the extension of the Victoria Docks, on the 13th inst.

Under the guidance of the resident engineer at the works, they were transported from the Silvertown station by the private railway of the contractors throughout the workings, and in doing so they were carried through a new tunnel, which dips under the new docks, and rises again to the surface on the other side. This portion of the line will be eventually used as part of the main line of the North Woolwich Railway.

The main feature of the dock extension is a basin (with two dry docks attached) 6,000 feet long, which lies in a line parallel to the Thames, and is situated in the North Woolwich marshes. In continuation of the basin, and separated from it by gates and a swing-bridge, is another basin, about 2,800 feet long, which further on debouches, by means of two locks, respectively 600 and 400 feet between the gates, into the Thames at Galleon's-reach, where two fine curved jetties protrude into the stream, affording an inviting haven to vessels entering the port.

These vast basins, affording quay space for nearly thirty first-class vessels at a time, are excavated 20 feet in the peat of the marshes, and the material thrown out is now used to raise the wharf 14 feet, to a level above highwater. The work is notable for its design and excellence of the material, in which there is nothing wanted. The members of Council, before leaving, inspected at work the steam excavator, constructed for the contractors by Messrs. Rushton and Proctor, of Lincoln. Performing the work of about 45 navvies, it differs from all others of its kind by being addicted neither to drink nor to kicking, and is never likely to be chargeable to the parish.

GENERAL NOTES.

Wilson's Clock-work Pen.—Mr. Wilson, of the firm of Newton, Wilson, and Co., has produced a pen of the same character as Edison's electric pen, which, however, is set in motion by clockwork instead of by a battery. The two pens produce identical results by perforating a sheet of paper, which forms a stencil, but Wilson's is more portable than Edison's. Mr. Wilson invented, some eighteen years ago, a pen that was operated like a fretwork machine for marking designs on work for the sewing machine, but the invention was not used and passed into oblivion. It has now been revived as a rival to the Edison pen.

Sanitary Exhibition at Cork.—An exhibition of sanitary and hygienic appliances will be held in Queen's College, Cork, from the 5th to the 8th of August, in connection with the annual meeting of the British Medical Association. The exhibition will be divided into the following departments:—I. Drainage, sanitary appliances, and disposal of refuse; II. Water supply, filtration, and river purification; III. Food, clothing, and disinfection; IV. Sanitary building appliances, plans and models, ventilation, heating, lighting, and consumption of smoke; V. Disposal of the dead; VI. Sanitary literature. The hon. secretaries for the exhibition are Mr. Arthur Hill, M.R.I.A., and Mr. W. H. Shaw, B.E., 22, George's-street, Cork.

NOTICES.

PROCEEDINGS OF THE SOCIETY.

AFRICAN SECTION.

Tuesday Evening, at Eight o'clock.

MAY 27.—"The Contact of Civilisation and Barbarism in Africa, Past and Present." By EDWARD HUTCHINSON, Esq., Lay Secretary of the Church Missionary Society. ARTHUR MILLS, Esq., M.P., will preside.

INDIAN SECTION.

Friday Evening, at Eight o'clock.

MAY 23.—"The Harbour of Kurachee." By W. J. PRICE, Esq., M.I.C.E. Sir WILLIAM MEREWETHER, C.B., K.C.S.I., will preside.

MEETINGS FOR THE ENSUING WEEK.

MON., MAY 26TH...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Karl Hillebrand, "The Intellectual Movement of Germany from the Middle of the Last to the Middle of the Present Century." (Lecture III.)
Society for the Development of the Science of Education, Memorial-hall, Farringdon-street, E.C., 7 p.m. Delivery of the Presidential Address.

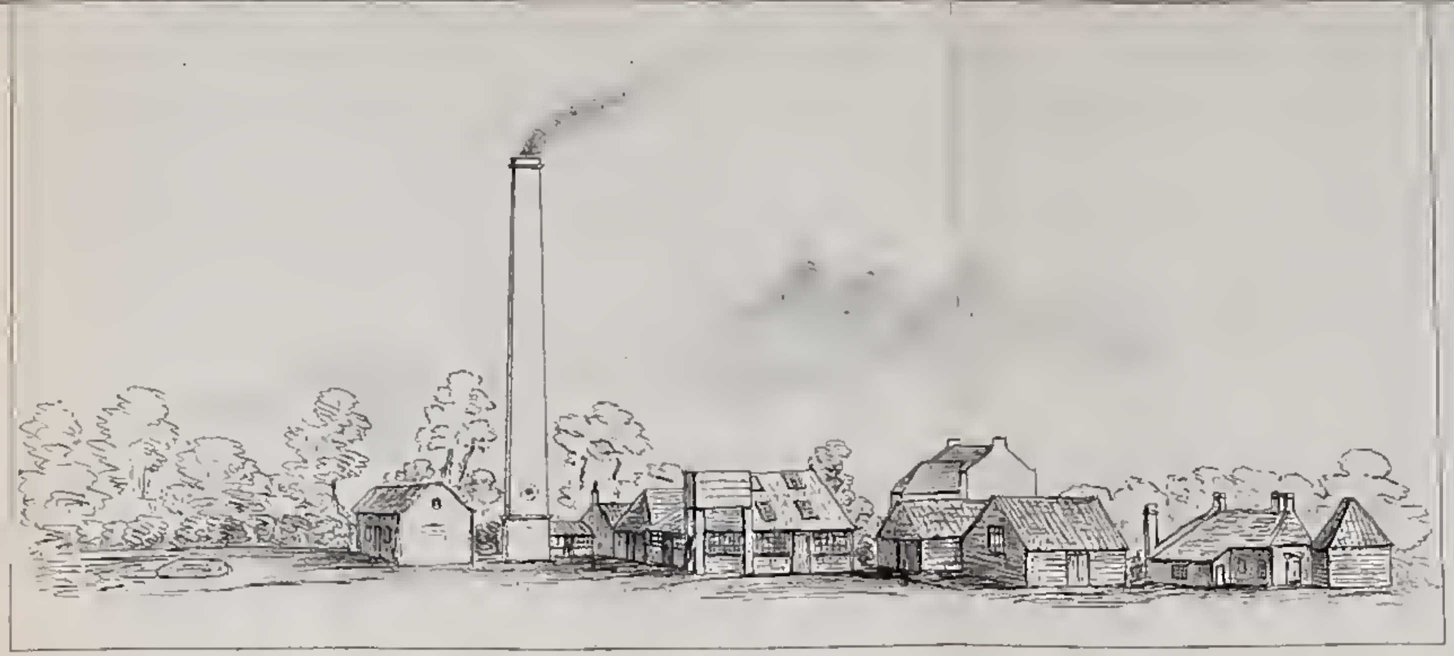
TUES., MAY 27TH...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (African Section.) Mr. Edward Hutchinson, "The Contact of Civilisation and Barbarism in Africa, Past and Present."
Royal Horticultural, South Kensington, S.W., 1 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. R. Seeley, "Suggestions to Students and Readers of History." (Lecture II.)
Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. A. F. Blandy, "Dock Gates."
Metropolitan Scientific Association, Ward Schools, 160A, Aldersgate-street, E.C., 7 p.m.
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Mr. Hodder M. Westropp, "Notes on Fetichism." 2. Mr. John Matthew, "Letters to Prof. Max Müller on the Kabi Dialect of Queensland."

WED., MAY 28TH...Geological, Burlington-house, W., 8 p.m. 1. Prof. R. Owen, "On the Endothiodont Reptilia, with Evidence of the Species *Endothiodon uniseries*, Owen." 2. Mr. J. W. Hulke, "Note on *Eucamerotus*, Hulke, = *Ornithopsis*, Seeley, = *Bothriospondylus*, Owen, = *Chondrosteatosaurus*, Owen." 3. Prof. T. Rupert Jones and Mr. James W. Kirby, "Description of the Species of the Ostracodous genus *Bairdia*, M'Coy, from the Carboniferous Strata of Great Britain." 4. Mr. R. Etheridge, jun., "Report on a Collection of Fossils from the Bowen River Coalfield and the Limestone of the Fanning River, North Queensland." 5. Dr. Henry Woodward, "A Fossil *Squilla* from the London Clay of Highgate, part of the Wetherell Collection in the British Museum." 6. Dr. Henry Woodward, "*Necroscilla Wilsoni*, a supposed Stomatopod Crustacean from the Middle Coal-measures, Cossall, near Ilkeston, Derbyshire." 7. Dr. Henry Woodward, "The Discovery of a Fossil *Squilla* in the Cretaceous Deposits of Hâkel, in the Lebanon, Syria." 8. Dr. Henry Woodward, "The Occurrence of a Fossil King-Crab (*Limulus*) in the Cretaceous Formation of the Lebanon, Syria."

THURS., MAY 29TH...Royal, Burlington-house, W., 8½ p.m. 1. Mr. C. Niven, "The Conduction of Heat in Ellipsoids of Revolution." 2. Dr. Shettle, "A New Method of Investigating the Magnetic Lines of Force in Magnets, Demonstrating the Obliquity of the Equator and Axis of Bar-magnets." 3. Mr. B. Stewart and Mr. W. Dodgson, "Preliminary Report to the Committee on Solar Physics on a Method of Detecting the Unknown Inequalities of a Series of Observations."
Antiquaries, Burlington-house, W., 8½ p.m.
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. Robert W. Edis, "The Furnishing of Town Houses."
Royal Institution, Albemarle-street, W., 8 p.m. Prof. Dewar, "Dissociation." (Lecture V.)
Philosophical Club, Willis's-rooms, St. James's, S.W., 6½ p.m.

FRI., MAY 30TH...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. Grant Allen, "The Colour-sense in Insects; its Development and Reaction."

SAT., MAY 31ST...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Henry Morley, "Swift." (Lecture II.)



THE WORKS IN 1858.

A.S. Cattell & Co. Litho.

COAL-TAR COLOUR WORKS, —— GREENFORD GREEN. 1873.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,384. Vol. XXVII.

FRIDAY, MAY 30, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

CONVERSAZIONE.

The Society's *Conversazione* is fixed to take place at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education) on Wednesday, the 25th of June. The cards of invitation will be issued shortly.

DOMESTIC ECONOMY CONGRESS.

The annual Congress on Domestic Economy will be held at the Society of Arts' Rooms, on Thursday, 26th June, at 11 a.m. till 5, with an adjournment at 1.30 till 2.30, together with an evening meeting at 7, for the convenience of School-teachers. The following subjects taught in Public Elementary Schools will be discussed in order :—Thrift, Discipline, Cleanliness of the Person; Needlework, Knitting, Netting, Clothing, Health; the Dwelling and its Cleanliness, Ventilation, and Warmth; Food and Cookery; Drill; Gymnastics; Recreation, Music, Games, &c. Intending speakers are requested to send brief heads of their proposed speeches, which will be printed if suitable, and if not exceeding 200 words.

NATIONAL WATER SUPPLY, SEWAGE, AND HEALTH.

As announced in the *Journal*, previous to the holding of the Annual Conference on the 16th and 17th ult., the Council of the Society offered One Gold and Three Silver Medals for the best suggestions for dividing England and Wales into districts, for the supply of pure water to the towns and villages in each district. The following Committee was appointed to adjudicate upon the papers sent in, in response to the offer:—Professor F. A. Abel, C.B., F.R.S., Mr. John Evans, Treas. R.S., Captain Douglas Galton, C.B., F.R.S., Professor Prestwich, F.R.S., Professor Ramsay, F.R.S., and Mr. G. J. Symons, F.R.S. The Committee reported to the Council in the following terms, and this report was read at the Conference:—

REPORT.

"The Committee have to report as follows:—They have held three meetings, and have carefully considered the suggestions sent in, in answer to the Society's offer of prizes. Twelve papers were sent in; of these the Committee selected seven as being worth printing for circulation at the Conference on Water Supply, &c.

"They are of opinion that none of the essays are worthy of a Gold Medal, but they have selected two which they think worthy of Silver Medals. These are —1st, the essay bearing the motto, 'Better Late than Never;' and, 2nd, the essay bearing the motto, 'Gutta cavat lapidem, non vi, sed sæpe cadendo.'

"Having made the awards, they proceeded to open the envelopes containing the names of the competitors, and they found that the essay bearing the motto, 'Better Late than Never,' was sent in by Mr. Frederick Toplis, and that bearing the motto, 'Gutta cavat lapidem,' &c., was sent in by Mr. Joseph Lucas. They also opened the envelopes containing the names of the other five competitors, and instructed the Secretary to write to each of them, asking whether he would wish his essay to be printed with his name to it, or merely under its motto.

"The Committee think that there are many points of merits in all the seven essays, but they are unanimously of opinion that the two they have selected for awards are much superior to any of the rest."

The following were the conditions of the offer:—

1. The Council of the Society of Arts offers One Gold and Three Silver Medals for the best suggestions, founded upon evidence already published, for dividing England and Wales into districts, for the supply of pure water to the towns and villages in each district.
2. The districts should be laid out on a skeleton map scale, which can be obtained from Mr. Stanford, 55, Charing-cross, price 6d. each.
3. The average rainfall in the district should be stated; also the population of the district, and its geology.
4. The suggestions should be written on foolscap, half-margin, and sent, accompanied by maps, under cypher, to the Secretary of the Society of Arts, on or before the 26th day of April, 1879.
5. The maps will be exhibited, and the suggestions will be discussed at the Conference on National Water Supply, to be held at the Society's Rooms, in May.
6. The Council will invite the assistance of eminent authorities to recommend the competitors worthy to receive the Prizes; but the Prizes will be withheld if the suggestions made do not appear to the Judges to be of sufficient merit.

BYE-LAWS OF THE SOCIETY.

Previous to the holding of the Annual General Meeting on the 25th proximo, the Council propose to summon a Special General Meeting of the Society, for the purpose of making certain alterations in the Society's Bye-laws, to come into force before the Annual General Meeting. Due notice of the date of the Special General Meeting will be given, in the manner directed by the Bye-laws.

PRACTICAL EXAMINATIONS IN MUSIC.

An examination for candidates residing in or near London has been arranged to be held at the House of the Society of Arts, during the week beginning June 16.

The examinations will be exclusively practical, and will take account of voice, style, ear, and reading.

Candidates in vocal music will be required—

1. To sing a solo, or to take part with another candidate in a duet, already studied. Credit will be given for the choice of the piece sung.

2. The pitch of a key-note being given, to name sounds or succession of sounds, played or sung by the examiner in that key and in the keys connected with it; *e.g.*, the dominant, subdominant, relative minor, or other.

3. To sing or solfa at sight passages selected generally from classical music.

Candidates in instrumental music will be required—

1. To play a piece already studied. Credit will be given for the choice of the piece played.

2. The pitch of a key-note being given, to name sounds, played by the examiner in succession or in combination, in that and its relative keys.

3. To play a piece or portion of a piece at sight.

The maximum of marks is 100. These will be distributed among the subjects of examination in the following proportion:—

Vocal Music.		
Voice	20	per cent.
Style	20	,,
Ear	20	,,
Reading	40	,,

Instrumental Music.		
Execution	20	per cent.
Style	20	,,
Ear	20	,,
Reading	40	,,

Candidates who obtain 75 marks will be entitled to a first-class certificate; and those who obtain 50 to a second. Candidates, the number of whose marks is below 30, will be entered as "not passed."

Before admission to the examination all candidates must have sent in a certificate, from a professor or other musical authority, to the effect that their qualifications are such as to afford a reasonable chance of their passing. Vocal candidates must come provided with a second copy of the solo or duet they have studied, in the established notation.

An accompanyist will attend the examination for vocal music, but candidates who prefer to do so, an bring an accompanyist with them.

Each candidate must pay a fee of 5s.

The examination will take place in the day or evening, according to the convenience of each candidate.

Intending candidates should at once communicate with the Secretary of the Society, stating if they desire to attend during the day or in the evening. They will then receive due notice of the day and hour fixed for their attendance.

CHEMICAL SECTION.

Thursday evenings, May 8th and May 22nd, 1879, Prof. F. A. Abel, C.B., F.R.S., in the chair. On these two evenings two lectures were given by Mr. W. H. Perkin, F.R.S., "On the History of Alizarin, &c."

The Chairman, before calling on the lecturer, said he desired, on the part of the Council, to express their most sincere sorrow at the untimely death of the talented chemist, who, up to this time, had conducted the business of this Section of the Society. They owed to Mr. Wills almost the creation of the Chemical Section, and to his zeal and untiring energy the maintenance of its interest and importance. He was a most promising young chemist, and his character as well as his talents were most highly esteemed, not only by his personal friends, but by all in his profession. He felt sure, therefore, that he should be only carrying out the wishes of all present in giving expression on their behalf, to their feelings of sympathy and condolence with his friends in their bereavement.

THE HISTORY OF ALIZARIN AND ALLIED COLOURING MATTERS, AND THEIR PRODUCTION FROM COAL TAR.

By W. H. Perkin, F.R.S.

Lecture I.—Delivered May 8.

In December, 1868, I had the honour of delivering three lectures before this society, on the "Aniline or Coal Tar Colours." In these I commenced with mauveine, or the mauve dye, the first discovered of this remarkable series of compounds, and then gave briefly the history of all the other important colouring matters which had been discovered up to that date.

Last year, Mr. Wills, who always arranged the business of this Section so assiduously, wished me to give a further account of these colouring matters, but I was unable to do so then. He, however, asked me again this year, and I was glad to be able to accede to his request, little thinking then, and still less only a few weeks since, when I met him full of activity and enthusiasm, that he would so soon be called from our midst, and his career here, so full of promise, ended.

When I promised to bring a paper before you, I thought that I would continue the history of the coal tar colours, from the time I gave the lectures just referred to up to the present time. However, on considering the subject in detail, I found the amount of matter far too large, owing to the great number of discoveries which had been made in this field since then; I therefore thought it best to confine myself to the consideration of the most important of the products which have been

obtained, and selected alizarin and allied colouring matters.

In giving you a somewhat brief account of this subject, I think it best first to refer to madder, the dye-stuff which, until 1869, was the only source of alizarin. Up to the date just mentioned madder-root was one of the most important dye-stuffs known, the annual value of the imports into the United Kingdom being about £1,000,000 sterling.

The plant that gives this root belongs to the natural order, *Rubiaceæ*. It is nearly allied botanically, and in appearance, to the ordinary Galiums, or bedstraws. It is a perennial, with herbaceous stem, which dies down every year, the stalk is square and jointed, and this and the leaves are rough with prickles. The flower is very small, and of a greenish yellow colour. The root is cylindrical and fleshy, and of a reddish yellow colour; this, when dried, constitutes madder. It is one of the oldest known dye-stuffs, and is referred to by Pliny. The principal varieties in cultivation are—*Rubia tinctorum*, *Rubia peregrina*, and *Rubia cardifolia*. It is grown in Holland, South of Germany, France, Italy, Turkey, and India. It has been cultivated also in this country, but not with permanent success. It is propagated from suckers, and the time from planting until the roots are drawn is from eighteen to thirty months, and sometimes longer. When dried, the roots lose their reddish yellow colour, and become of a pale red shade. The process of drying is conducted in the air, or in kilns. When dry, the roots are beaten to remove sand, clay, and loose skin. It is sent into the market either in this condition or in a ground state. There are also various preparations of madder made, the principal ones being *Fleur de garance*, or flowers of madder, and *garancine*. Their preparation is briefly as follows:—

Fleur de garance is made by soaking ground madder in water, with the addition of a small quantity of sulphuric acid: it is then drained in a filter and well washed. The washings contain a considerable amount of glucose, besides other products, and when fermented yield alcohol, which is suitable for a variety of purposes, but is not fit for drinking unless purified. The washed madder is then pressed and dried, and constitutes *fleur de garance*. On account of the products which have been removed, this substance is considerably richer in colouring matter than madder.

Garancine is prepared by first washing ground madder, much in the same way as for the preparation of *fleur de garance*, and after being pressed it is mixed with concentrated sulphuric acid, in quantity equal to about half the weight of the madder originally taken. After being thoroughly incorporated with this, it is heated with steam for three or four hours, placed on filters, and thoroughly washed, pressed, and dried. Tinctorially it is about three and a half times as strong as madder.

Madder will not dye unprepared fabrics; they require to be what is called mordanted. In this case the mordants consist of metallic oxides, those of aluminium and iron being the chief ones. With alumina mordants it produces shades of red and pink, with iron mordants shades of black and purple. These mordants may likewise be mixed, and then produce various kinds of chocolate colour. The value of madder, and its preparations, is determined by taking weighed quantities, and dyeing, pieces of mordanted cloth with them, the size of the cloth being always the same; after dyeing the patterns are cleared by treatment with soap, and are then dried; and, of course, according to the depth of the colour, so is the value. Standard specimens are used at the same time for the sake of comparison.

In mordanting cotton goods, the mordants, which are chiefly the acetates of iron and aluminium, are thickened and printed on, either with a machine or blocks. They are "aged," as it is called. This used to be performed by hanging the goods in a moist atmosphere for some days, but now they are passed through properly constructed rooms, kept at the requisite temperature and degree of moisture by steam, and then laid in bundles for a time.

The next process is called "dunging." Its object is to remove the thickening which has been used with the mordants, and also to thoroughly neutralise them, at the same time removing any that has not combined with the fibre. This is accomplished by passing the goods through warm water containing cow dung, but now more commonly containing certain salts, as phosphates, arseniates, &c.; these are called dung substitutes. When this operation has been finished the goods are washed, and are then ready for dyeing.

Dyeing with madder is an operation requiring considerable care, especially as the temperature of the dye bath must be raised only very slowly, otherwise a loss of colouring matter occurs. This makes the operation take some considerable time, often two hours. If garancin is used, the dyeing can be conducted more quickly. In this operation the ground madder, or the garancin is mixed with the water in the dye bath. A little chalk is also sometimes added. As the colouring matter of the dye stuff gradually dissolves in the water, the mordants on the goods take it up. It is important in this process that the mordants should be thoroughly saturated with colouring matter, otherwise they do not resist the after clearing process, so well. When dyed, the goods are washed with water and then cleared, as most of the colours are very impure, especially the reds, which have a rusty look. The methods of clearing vary according to the class of goods, madder pinks receiving the greatest amount of treatment and care. In this process soap is largely used, but it will not be necessary to enter into further details, as it would occupy too much time, and I only wish to convey to you a general impression of the application of madder to calico printing.

Before leaving this subject, I must refer to another most important application of madder, namely, Turkey red dyeing. This mode of dyeing was introduced into Europe from the East, and is undoubtedly of Indian origin; from India it came to the Levant, and was afterwards introduced into France about 1747. The first Turkey red works in the United Kingdom were established about the end of the last century. Turkey red is remarkable for its brilliancy of colour and permanence, and also for the peculiar nature of the processes employed in its production.

For dyeing Turkey red, the cotton is first prepared by treatment with olive oil, which is afterwards oxidised by exposure to the air. The oil is usually employed in the form of an emulsion, made

by agitating the oil with a solution of carbonate of soda or potash. The goods are passed through this, and then exposed to the air, after which they are treated several times in the same manner. When sufficiently charged with oxidised olive oil, they are mordanted with an alumina salt, galls, shumach, or other tannin matter. Cotton thus prepared for dyeing is of a buff or yellowish shade.

In the next operation, the dye bath is charged with madder or garancin, a little shumach, and a quantity of blood. The prepared goods are entered into this bath, and heat gradually applied, until it reaches the boiling point, at which temperature it is kept until the dyeing is complete. The goods are then washed in water, and present a dark, heavy, dull red colour. They are next subjected to the clearing processes, which are two in number. These are performed in large copper boilers, with moveable covers, as the clearing has to be done under pressure. The dyed goods are placed in these, with a mixture of common soda crystals and soap, and boiled under pressure for about six hours. They are then removed, washed in hot water, and again placed in boilers, with a solution of soap, to which chloride of tin (tin crystals) has been added. They are boiled in this, under pressure, for about four hours, and then removed, washed, and finished. The first clearing considerably improves the colour, but the last one gives that remarkable brilliancy peculiar to good Turkey red. After all this treatment with soap, we can understand that Turkey red is a very fast colour.

No satisfactory process for printing Turkey red has yet been found. Some time since, I made a few experiments on the subject. The cloth prepared ready for dyeing was used, and then printed with the colouring matter; it was then steamed, washed, and cleared as above. The colours were very good indeed, but the parts which should be white were still of the yellowish colour of the prepared cloth.

When a Turkey red is wanted in a pattern, the cloth is first dyed all over with this colour. If white is required in the pattern, those parts are printed with thickened tartaric acid; if yellow, with tartaric acid and a lead salt; if blue, with tartaric acid and Prussian blue. On passing cloth printed in this manner into a solution of chloride of lime, the parts printed with acid, as they come in contact with this solution, cause chlorine to be evolved, and the Turkey red destroyed, thus white is produced. If blue has been printed on with the acid, the red being discharged, blue remains. If a lead salt has been printed on, white is obtained; but when passed through a solution of bichromate of potash, yellow chromate of lead is formed. Of course green can be obtained by combining the last two processes. Black is printed on direct. Most beautiful results are obtained in this manner.

Madder is also employed for woollen goods. It is generally used in combination with other dyestuffs for the purpose of producing brown, buff, or chocolate colours. But I must pass on, the application of madder being a subject on which books have been written, my remarks are therefore necessarily of only a very general character, though I hope sufficient to give some idea of the processes.

Having seen the importance of madder as a dye stuff, and the methods of applying it to fabrics, it will next be desirable to consider the colouring matters it contains, which render it so valuable.

Scarcely anything was known of these until 1827. At this date, two chemists, Colin and Robiquet, obtained the principal colouring matter in a state of tolerable purity. They extracted ground madder with hot water, and, after treating this extract in various ways, obtained a product which, when heated carefully in a glass tube, gave off a yellowish vapour, condensing into brilliant bright red needles. They named this substance *Alizarin*, from the Levant name of madder, *Alizari*.

But the method they adopted for its preparation, viz., sublimation, rendered it a matter of uncertainty whether alizarin pre-existed in madder, or was a product of decomposition of some other body. Dr. Schunck, however, afterwards succeeded in obtaining it without having recourse to sublimation. If further proof were needed, it was found in the fact that this colouring matter was capable of dyeing mordanted cloth just in the same way as madder. It exists in madder in only very small quantities, not more than to the extent of one per cent.

Alizarin is nearly insoluble in cold water, and 1,000 parts of boiling water dissolved only about three parts of the colouring matter. It is more soluble in alcohol, and from high boiling naphtha it may be crystallised in red needles. When crystallised from alcohol, it is obtained in orange-coloured needles.

One of the characteristic properties of alizarin is the beautiful blue violet solution it produces on being dissolved in caustic alkalies. This solution, when viewed by the spectroscope, shows two strong absorption bands, one near to C, and the other at D, and a very faint one near to E. Alizarin, also, dissolves in ammonia with a purple colour. It forms a red lake with alumina, and a black one with oxide of iron.

Curiously, alizarin is not found in the growing madder root. This is easily seen by expressing some of its juice, and treating it with caustic potash. In this way a red-coloured solution is produced, and not a violet one, as would be the case if alizarin were present. This coloration is due to the presence of a substance called *rubianic acid*. This body is a glucoside of alizarin, and when decomposed yields alizarin and glucose. This can be easily effected by boiling it with hydrochloric acid, when alizarin separates as a yellow precipitate. Rubianic acid does not possess dyeing properties.

The decomposition of this glucoside in the madder root occurs partly during the process of drying, but not entirely until it is gently heated with water in the dye-bath. This decomposition is caused by a peculiar ferment called *Erythrozyme*, a product which is destroyed if heated with water to 100° C. This is one reason why the madder dyers have to gently raise the temperature of their dye-bath, so that this glucoside may entirely decompose, and all the alizarin be liberated and rendered useful. The importance of this may be easily seen, by taking two equal parts of growing madder root, and, after bruising them in a mortar, to throw one into boiling water, and the other into cold water. On placing a piece of mordanted cloth in each, keeping the one with boiling water still boiling, and gradually raising the temperature of the other,

it will be found that the one in boiling water will have scarcely coloured the mordants, whilst the one in cold water and gently warmed up will have dyed them thoroughly.

There is only one other colouring matter in madder that I need refer to, and that is purpurin. This substance was discovered by Colin and Robiquet, and called by them *Matière colorante rose.* It was afterwards obtained in a somewhat purer state by Debus, and by Wolff and Strecker. This substance is separated from madder by boiling it with a solution of alum; munjeet, however, is its best source. It is precipitated from the alum solution with hydrochloric acid and then further purified. When pure purpurin crystallises in red or orange red needles, it differs from alizarin in the way it behaves with alkalies, solutions of these yielding with it beautiful cherry-red colours. It also disolves in alumina salts with formation of pink solutions, which are fluorescent. The spectrum is also very different from that of alizarin.

It dyes mordanted cloth, forming with alumina mordants a yellowish scarlet. The colours it produces with iron mordants, however, are not at all good. The purpurin colours do not resist soaping well, so that madder prints, in the process of clearing, lose all the purpurin taken on in the dye-bath. It is retained, however, to some extent in the cheaper class, such as garancine styles. From this it will be seen that it is a substance of but little value. It exists in the growing madder-root as a glucoside.

A great deal of controversy has taken place respecting the chemical formula of alizarin. Dr. Schunck proposed $C_{14}\ H_{10}\ O_4$, which, according to the present notation, would be $C_7\ H_5\ O_2$, whilst Strecker believed it to be $C_{10}\ H_6\ O_3$, and related to chloroxynaphthalic acid, a derivative of naphthalene, so that it has long been supposed that it was possible to obtain alizarin from a coal-tar product, though not from the right one. Still there was a good deal of reason to believe that it was a naphthalene derivative, from the fact that, when oxidised it yields the same acid as naphthalene, namely, phthalic acid. Strecker's formula was the one generally believed in. It is right to mention that Strecker changed his views of this subject afterwards.

The chloroxynaphthalic acid above referred to was supposed to be a chlorine derivative of alizarin, the two bodies being thus related:—

$C_{10}\ H_6\ O_3$	$C_{10}\ H_5\ Cl\ O_3$
Alizarin.	Chlorinated Alizarin.

And many attempts were made to remove this chlorine, and replace it by hydrogen, so as to form alizarin; and eventually Martius and Greiss obtained the substance, $C_{10}\ H_6\ O_3$, when investigating some amido derivatives of naphthal, but it was not alizarin. They assumed it, however, to be an isomer of that body.

Some time after the experiments of Martius and Griess, Graebe commenced some researches on quinone (a body related to benzene). At that time no analogous substance to quinone, related to any other hydrocarbon than benzene, was recognised. However, he was induced to consider chloroxynaphthalic acid as a derivative of a naphthalene quinone, which has since been obtained, and also discovered a chlorinated derivative of a quinone of toluene.

The attention of Graebe, in conjunction with Liebermann, was then turned to alizarin, which they thought probably might belong to the quinone series; but it was important that they should first know to what hydrocarbon it was related. To obtain that information, alizarin prepared from madder was taken and heated with powdered zinc, according to Baeyer's method of reducing aromatic compounds, and in this manner they obtained a crystalline hydrocarbon, having the composition, $C_{14}\ H_{10}$. This was shown to be anthracene, a hydrocarbon contained in coal-tar. Reasoning from the information which they had thus obtained, they assumed alizarin to be a dioxyquinone acid of anthracene—

$C_{14}\ H_{10}$	$C_{14}\ H_8\ O_2$	$C_{14}\ H_6\binom{OH}{OH}O_2$
Anthracene.	Anthraquinone.	Alizarin.

But, to prove this to be the case, it was necessary to produce alizarin from anthracene.

This hydrocarbon was discovered by Dumas and Laurent in 1832. They obtained it from the product which comes over towards the end of the distillation of coal-tar. They gave it the formula $C_{15}H_{12}$, and, as this was one and a-half times the molecular weight of naphthalene, they called it paranaphthalene. It was further examined by Laurent, who changed its name to anthracene. He also obtained from it a body which he called anthracenuse, by oxidising it with nitric acid; to this he gave the formula $C_{15}\ H_8\ O_4$ and $C_{15}\ H_7\ O_5$.

In 1854-55, when studying under Dr. Hofmann, at his suggestion I took up the subject of anthracene for my first investigation. I prepared the hydrocarbon by distilling pitch. Dr. Hofmann afterwards kindly obtained for me, from Messrs. Bethel, several pounds of a product rich in anthracene. On oxidising anthracene, I obtained a product to which I assigned the formula $C_{14}H_{10}\ O_2$, and, not doubting Laurent's formula for the hydrocarbon anthracene, believed this oxygenated product to be derived from it by loss of carbon and hydrogen. These results were not published, and I only mention them here because it was through the experiments I then made that I obtained much information, which afterwards proved to be of great value to me; and, moreover, the products I then made served for the experiments to which I shall have to refer presently.

In 1857, Fritsche examined a hydrocarbon from coal-tar, to which he gave the formula $C_{14}\ H_{10}$, and showed that it had many properties in common with anthracene.

In 1862, Dr. Anderson published an account of his investigations on anthracene. He found it to possess the formula $C_{14}\ H_{10}$, and to be identical with Fritsche's hydrocarbon. Dr. Anderson also prepared the oxidation product, and found it to contain $C_{14}\ H_8\ O_2$. He called it oxanthracene; it is identical with Laurent's anthracenuse, and with the product I obtained.

Graebe and Liebermann at once recognised this as the quinone of anthracene. It, therefore, only remained for them to convert this into the quinone acid, by replacing two atoms of hydrogen by hydroxyl, and thus settle the question as to whether alizarin be a quinonic acid of anthracene or not.

The process they adopted has long been used by chemists; it consists in first replacing the hydrogen of the compound with bromine or other halogen, and then treating the resulting body with sodic, potassic or other metallic hydrate, and according as one, two, or more atoms of hydrogen have been replaced by bromine, so on its removal by the metal of the hydrate, a compound containing a corresponding number of atoms of hydrogen replaced by hydroxyl is obtained.

Acting upon this principle, Graebe and Liebermann heated anthraquinone in sealed tubes, with bromine, in the proper proportions, to obtain a dibromanthraquinone, $C_{14} H_6 Br_2 O_2$. And this substance, when fused with caustic potash, yielded alizarin in combination with the alkali, from which it was separated by means of an acid. They also proposed a second method for preparing dibromanthraquinone, viz., by oxidising tetrabromanthracene—

$$C_{14} H_6 Br_4 + O_2 = C_{14} H_6 Br_2 O_2 + Br_2.$$

The great importance of alizarin, as a dyeing agent, induced Graebe and Liebermann to patent their process, but it was of no commercial value. They had, however, solved the question of its relationship to anthracene and anthraquinone, and also established its formula—

$$C_{14} H_6 \binom{OH}{OH} O_2$$

Strecker, in 1866, had given the correct formula for alizarin, but did not publish it in the ordinary way results of research are usually published, but adopted it in his "Traité de Chimie Organique." And it was not until he drew my attention to the fact, that I became aware of it. He also states that he instituted experiments in 1855, in conjunction with Staedel, to establish the relationship between alizarin and anthracene. Graebe and Liebermann appear to have had no knowledge of this.

On distilling purpurin, the other colouring matter of madder previously referred to, Graebe and Liebermann also obtained anthracene, and this confirmed the formula Strecker had assigned to this substance, viz., $C_{14} H_8 O_5$.

Purpurin is anthraquinone, with three atoms of hydrogen replaced by hydroxyl.

$$C_{14} H_5 \left\{ \begin{matrix} OH \\ OH \\ OH \end{matrix} \right\} O_2$$

Graebe and Liebermann's process for the preparation of alizarine being found to be impracticable, it was desirable, if possible, to find a new method which would render their discovery of commercial value.

It has been known for a very long time, that sulphuric acid acts upon many organic bodies, producing substances called sulpho acids. In composition, these represent the body acted upon *plus* sulphuric anhydride. The basicity of the product (if derived from a neutral body) increasing with the number of molecules of sulphuric anhydride used in its formation. These so-called sulpho-acids have been found, however, to be nothing more than acid sulphites; thus the acid produced by the combination of benzol with one molecule of sulphuric anhydride, is an acid sulphite of phenyl, or phenyl-sulphurous acid:—

$$\underbrace{C_6 H_6 SO_3}_{\text{Sulphobenzolic acid.}} = \underbrace{C_6 H_5 SO_3 H}_{\text{Phenylsulphurous acid.}}$$

And that obtained by combining napthalin with two molecules of sulphuric anhydride, is an acid disulphite:—

$$\underbrace{C_{10} H_8 (SO_3)_2}_{\text{Disulphonaphthalic acid.}} = \underbrace{C_{10} H_6 \left\{ \begin{matrix} SO_3 H \\ SO_3 H \end{matrix} \right.}_{\text{Naphthylene-sulphurous acid.}}$$

The experiments of Würtz and Kekulé, in 1867, confirmed this view of the constitution of these acids. They found that sulpho-benzolic acid, when heated with caustic potash, produced a phenate and sulphite, thus:—

$$\underbrace{C_6 H_5 SO_3 H}_{\text{Sulpho-benzolic acid.}} + 3 K HO =$$

$$\underbrace{C_6 H_5 OK}_{\text{Potassic phenate.}} + SO_3 K_2 + 2 OH_2$$

In the same year Dusart also found that disulphonaphthalic acid yielded in the same way a naphthylenate and a sulphite.

$$\underbrace{C_{10} H_6 \left\{ \begin{matrix} SO_3 H \\ SO_3 H \end{matrix} \right.}_{\text{Disulphonaphthalic acid.}} + 6 KHO =$$

$$\underbrace{C_{10} H_6 \left\{ \begin{matrix} OK \\ OK \end{matrix} \right.}_{\text{Potassic naphthylenate.}} + 2 SO_3 K_2 + 4 OH_2$$

By the addition of an acid to the products of these reactions, they obtained, first from benzol, by means of the sulpho acid, hydrate of phenyl, phenol or carbolic acid, and from naphthylene, the dihydrate of naphthylene.

$$\underbrace{C_6 H_6}_{\text{Benzol.}} \qquad \underbrace{C_6 H_5 OH}_{\text{Hydrate of phenyl.}}$$

$$\underbrace{C_{10} H_8}_{\text{Naphthylene.}} \qquad \underbrace{C_{10} H_6 \left\{ \begin{matrix} OH \\ OH \end{matrix} \right.}_{\text{Dihydrate of naphthylene.}}$$

In this second example, it will be seen that we have obtained a body standing to naphthylene as alizarin does to anthraquinone. In other words, two atoms of hydrogen have been replaced by two hydroxyls.

It therefore appeared probable to me that, if a disulpho acid of anthraquinone could be produced, alizarin might possibly be obtained by a similar process.

From my previous knowledge of the remarkable stability of anthraquinone, and that it might be dissolved in strong hot sulphuric acid, and would then crystallise out unchanged on cooling, it did not appear very probable that a sulpho acid could be formed; nevertheless, experiments were made, varying temperatures

being employed, when eventually it was found that by heating a mixture of sulphuric acid and anthraquinone very strongly, combination actually took place, the mixture becoming perfectly soluble in water. After removing the excess of sulphuric acid from the new product, it was mixed with caustic potash, and heated to about 180° C.; it soon became coloured, and then black. When the reaction was considered complete, the black alkaline mass was dissolved in water, and formed a rich purple solution. On acidifying this, it became yellow, from the separation of a copious precipitate, which, on examination, proved to be artificial alizarin. This product, when collected on a filter and thoroughly washed, was found to dye madder mordants with the greatest readiness.

The great obstacle to the preparation of alizarin, viz., the use of bromine was thus removed, and, as the future has proved, a process had been obtained by which this colouring matter could be manufactured in quantity.

I may here mention that, while these experiments were in progress, Caro, Graebe, and Liebermann were investigating the same reaction in in Germany.*

A short time after I had discovered this method of making artificial alizarin, I found an entirely new process, in which anthraquinone is not required at all.†

Anthracene forms with chlorine a beautifully crystalline body, called dichloranthracene, having the formula, $C_{14} H_8 Cl_2$. This substance comcombines with Nordhausen sulphuric acid, forming a bright green solution, which consists of a sulpho acid of dichloranthracene. This compound undergoes a remarkable change when heated with sulphuric acid, hydrochloric acid, and sulphurous anhydride being evolved, and a sulpho acid of anthraquinone formed. This process has proved to be of great value, as will be seen further on.

When artificial alizarin was first manufactured, it was noticed that the colours produced by it differed, to some extent, from those produced with madder or alizarin. The red shades were more brilliant and more scarlet, and the purples bluer; the blacks were also more intense, and some persons went the length of saying that alizarin had not been produced artificially at all. This I refuted in a paper read before the Chemical Society in May, 1870,‡ when I showed that alizarin could be readily separated from the commercial product, and then possessed all the properties of natural alizarin, both as regards its dyeing power, and in its other characteristics. As no doubt now exists on this point, I think I need not further discuss it.

In a foot note* in the paper just referred to, I stated that "when purifying artificial alizarin by converting it into an alumina lake, I found that, upon digestion with carbonate of potash, this lake gave a red coloured solution, containing a colouring matter, dyeing mordants very similarly to alizarin, with the difference that the reds were more scarlet, and the purples bluer or more slaty. I have not obtained this body in a perfectly pure state as yet, but it appears to be crystalline. It gives two faint black bands when examined in alkaline solution with the prism, but these may perhaps be due to the presence of traces of alizarin." Some time after this, I made a complete examination of this substance,† and my analytical results showed it to have the same composition as natural purpurin, viz.:—

$$C_{14} H_5 \left\{ \begin{matrix} OH \\ OH \\ OH \end{matrix} \right\} O_2$$

though it differs from it in properties, in fact, it is an isomeride of that substance. Being a derivative of anthracene, I therefore named it anthrapurpurin. Auerbach,‡ in 1872, separated a colouring matter from artificial alizarin. He named it isopurpurin. It is, however, identical with anthrapurpurin. The name isopurpurin is now mostly used for this substance on the Continent.

The importance of anthrapurpurin as a colouring matter can scarcely be over-rated. I believe I may truly say it is of as great importance as alizarin itself, and its existence in artificial alizarin has been the cause of its marvellously rapid success., as it gives a brilliancy to the reds which cannot be obtained with madder. Anthrapurpurin differs from alizarin in many particulars. When heated, it is mostly decomposed, only a little subliming in orange-red vapours, and condensing as yellowish red leaves. If a mixture of anthrapurpurin and alizarin be sublimed, the sublimate will consist almost entirely of alizarin, as this substance is not so easily decomposed by heat.

Anthrapurpurin dissolves in caustic alkalies with a more purple colour than alizarin. It also differs in its behaviour with alumina. A solution of anthrapurpurin in sodic carbonate, when mixed with freshly precipitated alumina, is not absorbed by it, whereas alizarin under the same conditions is perfectly absorbed. It crystallises in orange yellow needles, from alcohol or glacial acetic acid.

By heating it with acetic anhydride I obtained a triacetyl derivative, and by using benzoyl chloride, a tribenzoyl one, thus showing it to contain three replaceable hydrogens. Its alkaline solutions give two faint absorption bands when viewed with the spectroscope, these bands being in the same region of the spectrum as those produced with alkaline solutions of alizarin. When oxidised with nitric acid, it does not yield phthalic acid.

On heating anthrapurpurin with ammonia to a temperature of 160-180° C., in a closed tube, I

* Graebe and Liebermann, in a paper published in the *Moniteur Scientifique*, April, 1879, p. 399, state that "Caro was the first to observe that anthraquinone, when heated with sulphuric acid above 200°, formed sulphoconjugated acids, which, like the brominated compound, gave alizarin on fusion with potassium hydrate; soon afterwards, or almost at the same time, Perkin made the same observation." Again, at pp. 400-401, they state "The patent of Caro, Graebe, and Liebermann is dated a day before that of Perkin. If any particular importance is attached to dates, the advantages rests without dispute with Caro, for the filing of the patent of the German chemist was delayed through irregularity (*vice de forme*). The signatures had already been given in to the Patent-office, Berlin, on the 15th June." I may remark, in reference to the first statement, that Graebe and Liebermann neither give or adduce any evidence to substantiate their claim to priority. Their remark that I had soon afterwards, or almost at the same time, made the same observation, also goes to show that they have none. And in reference to the statement that their signatures had been given in to the Patent-office, Berlin, on the 15th June, I find that on May 20th, I wrote to Mr. Robert Hogg, of Glasgow, enclosing patterns dyed with artificial alizarin, which I had prepared by fusing the sulphoconjugated acids of anthraquinone with potassium hydrate, and my patent might then have been secured, but was delayed. Therefore, their conclusions, from the argument as to dates, should be reversed.

† Patented November, 1869, No. 3,318.

‡ *Journal of the Chemical Society*, 1870, p. 133.

* *Journal of the Chemical Society*, 1870, p. 143.

† *Journal of the Chemical Society*, 1872, p. 659; 1873, p. 425.

‡ *Moniteur Scientifique*, 1872, p. 686.

found it changed into an amidated compound, which has been named anthrapurpuramide. This substance does not dye mordants. Its solution in alcohol is of a clear dark orange-red colour. It dissolves in alkalies with a purple colour. Anthrapurpuramide is isomeric with amido alizarin. Its formula is—

$$C_{14}H_5 \left\{ \begin{matrix} NH_2 \\ OH \\ OH \end{matrix} \right\} O_2$$

In my paper on anthrapurpurin, it is mentioned that there is a colouring matter in artifical alizarin dyeing alumina mordants of an orange colour.* This was afterwards obtained in a crystalline condition, and was under investigation for some time, but the research was laid aside on account of more pressing subjects. This substance, however, proves to be flavopurpurin, a colouring matter lately described by Schunck and Roemer,† and obtained by them from anthraflavic acid. It has the formula—

$$C_{14}H_5 \left\{ \begin{matrix} OH \\ OH \\ OH \end{matrix} \right\} O_2$$

and is therefore isomeric with anthrapurpurin.

The amount of it contained in artificial alizarin is not very large. It is much more freely soluble in alcohol than anthrapurpurin, and crystallises from that solvent in orange-coloured silky needles. Its alcoholic solution, when poured into water, forms a yellow precipitate; this, however, has a satiny aspect, owing to the crystalline character of the precipitate; it dissolves in caustic alkali with a purple colour, redder than that produced with anthrapurpurin, and in ammonia it forms a brownish red colour, anthrapurpurin forming a purple solution.

Flavo-purpurin dyes mordants, but the colours on those of alumina are of an orange-red colour, the pinks being somewhat of a salmon shade. The purples are more like those of alizarin, but very dull in comparison with them.

In artificial alizarin, I believe there is yet another colouring matter not investigated, dyeing alumina mordants a still yellower shade than flavopurpurin. It is apparently present in very small quantities.

We now see that the product at first made, and called "artificial alizarin," contained at least three colouring matters, viz., alizarin, anthrapurpurin, and flavopurpurin; as I think it will be convenient to retain this name at present for simplicity sake, it will be understood that, when I use it, I do not refer to pure alizarin, but to commercial products known by that name.

Before proceeding to speak of some of the products found in artificial alizarin, I wish to draw attention to a soluble intermediate substance which is obtained in its preparation, if the process of heating with caustic soda be not carried on sufficiently long. In this case, although the alkaline product dissolved with a strong violet colour, I noticed that, when acidified, no colouring matter, or only a small quantity was precipitated,

* *Journal of the Chemical Society*, 1873, p. 425.
† Deut. Chem. Ges. Ber., 1876, p 679.

a strong dark yellow solution being obtained. On isolating this body, it was found to be crystalline, forming orange-coloured needles, easily soluble in water, but insoluble in ether. With alkalies, it forms a blue violet-coloured solution; it does not dye mordants. When fused with caustic alkali it is converted into anthrapurpurin. From the mode of its formation and from its decomposition with alkalies I gave it the formula:—

$$C_{14}H_6 \left\{ \begin{matrix} OH \\ SO_3H \end{matrix} \right\} O_2$$

and named it sulphoxanthraquinonic acid.* Some time afterwards, Graebe and Liebermann† further investigated this compound, and confirmed this formula. With the alkaline earths it forms two sets of salts—acid and neutral ones—the former being of a yellow colour; the latter violet. These probably could be used as pigments.

The artificial alizarin, as first made, contained not only three colouring matters, but also other products not possessing dyeing powers. These are of considerable interest, as will be seen further on. Amongst these are anthracene, anthraquinone, and hydroanthraquinone, products which are the result of a peculiar reverse action, or process of reduction, which takes place in the preparation of artificial alizarin during the operation of heating with caustic alkali. The first, viz., anthracene, was only formed in the early experiments, and resulted from overheating. But the two other substances are always obtained if caustic alkalies alone are used. Of anthraquinone I have already spoken, but I have not referred to the action of reducing agents upon it. If anthraquinone be mixed with a solution of caustic potash and zinc dust, the liquid quickly becomes red, especially if heated, the anthraquinone dissolving. This liquid may be filtered; but as the oxygen of the air quickly acts upon it, films of anthraquinone are formed; if the air be excluded, a clear red-coloured fluid is obtained, and on the addition of an acid, a yellow precipitate is formed. This substance is hydroanthraquinone, produced from anthraquinone by its union with hydrogen. Its formation may be represented thus:—

$$\underbrace{C_{14}H_8O_2}_{\text{Anthraquinone.}} + H_2 = \underbrace{C_{14}H_{10}O_2}_{\text{Hydroanthraquinone.}}$$

The other bodies I have to speak of are not due to any reverse chemical action, but are the products of direct changes, and were regarded as secondary products.

On boiling up artificial alizarin with dilute caustic soda, and adding milk of lime, it was found that the colouring matter was precipitated, leaving a yellow or orange-coloured solution. On filtering this off, and adding an acid to the filtrate, a pale yellow precipitate was obtained. A quantity of this was prepared, washed, and dried, and from some of it Dr. Schunck‡ succeeded in isolating a beautiful yellow crystalline product. This he called anthraflavic acid, and assigned to it the formula, $C_{15}H_{10}O_4$. Not being satisfied with this formula, I afterwards submitted it to investigation,§ and

* *Journal of the Chemical Society*, 1870, p. 139.
† "Jahresbericht," 1871, p. 685.
‡ Proc. Lit. and Phil. Soc., Manchester, vol. x., p. 133.
§ *Journal Chemical Society*, 1871, p 1109.

showed it to have the composition $C_{14}\ H_8\ O_4$, which has since been confirmed by others. This formula is the same as that of alizarin, and, therefore, anthraflavic acid is an isomeride of that substance. It is prepared from its barium salt, which is somewhat difficultly soluble in water.

Anthraflavic acid is a beautiful substance, crystallising in bright yellow silky needles, and, when heated, gives a sublimate of golden yellow crystals, in the form of leaves or plates, a certain amount being, at the same time, carbonised. It does not dye mordants. It combines with alkalies, forming compounds, dissolving in water with an orange red colour. The barium salt, already referred to, crystallises in needles of a brownish red colour, and its cold aqueous solution is somewhat similar in appearance to that of potassic bichromate.

Dr. Schunck found that anthraflavic acid, when fused with caustic potash, was converted into a colouring matter, which he thought to be alizarin. I also believed this to be the case until some time afterwards, when I prepared a sufficient quantity of the colouring matter to dye a pattern with. I then found it produced orange red colours, with alumina mordants.*

Schunck and Roemer† have since investigated this reaction, and found that the colouring matter is an isomer of anthrapurpurin; in fact, it is flavopurpurin, which has already been described. Its formation may be expressed thus—

$$\underbrace{C_{14}H_8O_4}_{\text{Anthraflavic acid.}} + 3OKH = \underbrace{C_{14}H_5K_3O_5}_{\text{Potassic flavopurpurate.}} + H_2 + 2OH_2$$

To effect this change in small experiments, a temperature over 200° C. is necessary.

Dr. Schunck and H. Roemer‡ have published an account of another substance which accompanies anthraflavic acid. They have named it isoanthraflavic acid. I had also succeeded in obtaining this substance, and also in preparing it without the formation of colouring matter, except in small quantities.§ To this I shall refer presently.

Isoanthraflavic acid crystallises from glacial acetic acid, in which it is difficultly soluble, in yellow needles. These lose their lustre on being dried at 100°C. When strongly heated, it sublimes in leaves of a golden or orange colour. This substance has the formula—

$$C_{14}H_6\left\{\begin{matrix}OH\\OH\end{matrix}\right\}O_2$$

and is, therefore, another isomer of alizarin. It differs from anthraflavic acid, in forming a barium derivative, which is easily soluble in cold water with a dark red colour. Heated with acetic anhydride, it forms a pale yellow crystalline body, having the formula—

$$\underbrace{C_{14}\ H_6\left\{\begin{matrix}OC_2H_3O\\OC_2H_3O\end{matrix}\right\}O_2}_{\text{Diacetoisoanthraflavic acid.}}$$

When heated to about 180° C. with caustic potash, it undergoes a very interesting change. The mixture gives a black-looking product, which dissolves in water with a beautiful purple colour. On acidifying this with an acid, a yellow precipitate is formed, which is found to consist of anthrapurpurin. This change is similar to that which takes place when anthraflavic acid is treated with caustic alkalies, but occurs at a much lower temperature. This reaction is as follows:—

$$\underbrace{C_{14}\ H_8\ O_4}_{\text{Isoanthraflavic acid.}} + 3OKH =$$

$$\underbrace{C_{14}\ H_5\ K_3\ O_5}_{\text{Potassic Anthrapurpurate.}} + H_2 + 2\ OH_2$$

Isoanthraflavic acid does not dye mordants.

Another substance was found in artificial alizarin, as a bye-product, by Caro and Glaser. It was first examined in 1871 by Liebermann,* who found it to have the formula:—

$$C_{14}\ H_7\ (OH)\ O_2$$

and named it monoxanthraquinone. It crystallises from alcohol in fine yellow needles. It does not dye mordants.

Monoxanthraquinone, when fused with alkalies, also undergoes an interesting change. It becomes a nearly black mass, which dissolves in water with a blue-violet colour, and this solution, on being acidified, gives a yellow precipitate, which is nothing but pure alizarin.

$$\underbrace{C_{14}\ H_7\ (OH)\ O_2}_{\text{Monoxanthraquinone.}} + 2\ OKH =$$

$$\underbrace{C_{14}\ H_6\left\{\begin{matrix}OK\\OK\end{matrix}\right\}O_2}_{\text{Potassic Alizarate.}} + H_2$$

Now, how can the presence of monoxyanthraquinone, anthraflavic, and isoanthraflavic acid in artificial alizarin be accounted for? When sulphuric acid acts upon anthraquinone, two kinds of sulpho acids are formed, namely, a mono and a di.

$$\underbrace{C_{14}\ H_7\ (SO_3H)\ O_2}_{\text{Monosulphanthraquinonic acid.}} \qquad \underbrace{C_{14}\ H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}O_2}_{\text{Disulphanthraquinonic acid.}}$$

After the manufacture of alizarin had been commenced, Graebe and Liebermann published an account of these bodies.†

They found that monosulphanthraquinonic acid, when heated carefully with alkali, yields monoxanthraquinone.

$$C_{14}\ H_7\ (SO_3\ H)\ O_2 + 3\ OKH =$$

$$\underbrace{C_{14}\ H_7\ (OK)\ O_2}_{\text{Potassic monoxanthraquinonate}} + SO_3\ K_2 + 2\ OH_2$$

And this, when further heated, yielded alizarin as previously stated. The disulpho acid, when heated with alkali, they said, formed alizarin.

$$C_{14}\ H_6\left\{\begin{matrix}SO_3\ H\\SO_3\ H\end{matrix}\right\}O_2 + 6\ KHO =$$

$$C_{14}\ H_6\left\{\begin{matrix}OK\\OK\end{matrix}\right\}O_2 + 2\ SO_3\ K_2 + 4\ O\ H_2$$

* *Journal of the Chemical Society*, 1873, p. 20.
† Deut. Chem. Ges. Ber., 1876, p. 679.
‡ Deut. Chem. Ges. Ber., 1875, p. 1628, and 1876, p. 379.
§ *Journal of the Chemical Society*, 1876, i, 851.

* Deut. Chem, Ges. Ber., 1871, p. 108.
† Jahresbericht, 1871, 683—684.

This, as we shall see presently, was a mistake, probably from the fact that the need of a disulpho acid for the preparation of alizarin had never been doubted, the process being supposed to be analogous to that originally described with dibromanthraquinone.

But it was gradually found, when manufacturing artificial alizarin on the large scale, that the smaller the amount of sulphuric acid used to convert the anthraquinone into sulpho acids, the temperature being also kept as low as practicable, that the colouring matter made from such a product yielded with mordants shades of colour more nearly approaching those produced with madder, until eventually the unexpected result was arrived at, that it was necessary to have a monosulpho acid of anthraquinone for the preparation of pure alizarin, and that the disulpho acid does not yield this substance at all, so that, in the preparation of pure alizarin, the following reactions take place, mono ulphanthraquinonic acid is first decomposed into monoxanthraquinone; and this, when further heated with alkali, is oxidised into alizarin.

We thus see that this formation of alizarin differs entirely from that originally discovered by Graebe and Liebermann, both as regards the chemicals employed and the chemical changes which take place. We also see that monoxanthraquinone is an intermediate product and not a secondary one.

Disulphanthraquinonic acid, although it does not yield alizarin when heated with alkalies, yields anthrapurpurin. But how is this to be accounted for? It has been shown that the first action of caustic alkali on this acid results in the formation of sulphoxanthraquinonic acid:—

$$C_{14} H_6 \left\{ \begin{matrix} OH \\ SO_3 H \end{matrix} \right\} O_2$$

This, when further treated with the same reagent, changes into anthrapurpurin:—

$$C_{14} H_5 \left\{ \begin{matrix} OH \\ OH \\ OH \end{matrix} \right\} O_2$$

When I became fully acquainted with this fact, I was under the impression that an intermediate body must be formed, standing to anthrapurpurin as monoxanthraquinone does to alizarin, and formed simply by the replacement of the $SO_3 H$ group in sulphoxanthraquinonic acid by HO.

Such a substance was found in artificial alizarin, and I have already described it; it is isoanthraflavic acid. In proof of its being always formed previously to anthrapurpurin, I succeeded in obtaining it directly by heating a salt of disulphanthraquinonic acid with a dilute solution of caustic potash. I employed a five per cent. solution of this alkali, and only little more than a sufficient amount to effect the decomposition indicated by theory, thus:—

$$\underbrace{C_{14} H_6 \left\{ \begin{matrix} SO_3 H \\ SO_3 H \end{matrix} \right\} O_2}_{\text{Disulphanthraquinonic acid.}} + 6\ OKH =$$

$$\underbrace{C_{14} H_6 \left\{ \begin{matrix} OK \\ OK \end{matrix} \right\} O_2}_{\text{Potassic Isoanthraflavate.}} + 2\ SO_3K_2 + 4\ OH_2$$

The mixture was heated in a closed iron vessel to 180-190° C for six or seven hours. In this manner scarcely any anthrapurpurin was formed, and the alkaline solution, when acidified, gave a precipitate consisting chiefly of isoanthraflavic acid. So that in the formation of anthrapurpurin from disulphoanthraquinonic acid we get the following changes:—First, the formation of sulphoxanthraquinonic acid; second, the formation of isoanthraflavic acid; third, the formation of anthrapurpurin; and we see that isoanthraflavic acid is also an intermediate product in the formation of anthrapurpurin, and not a secondary one. The formation of anthraflavic acid has now to be accounted for. When sulphuric acid acts upon anthraquinone, it is found to form two isomeric disulpho acids, one forming an easily soluble sodium salt, the other a less soluble one. The former is known as the β sodic disulphanthraquinonate, the latter as the α. This less soluble or α salt, when treated with alkalies, undergoes analogous changes to the β salt, but, instead of forming isoanthraflavic acid, yields anthraflavic acid, and this, as previously stated, when heated strongly with alkalies yields flavopurpurin. Anthraflavic acid is, therefore, an intermediate body and not a secondary one.

We see, then, how these various bodies are formed, and as they are proved to be intermediate products, their presence shows imperfection in the process of manufacturing, because, if perfect, these substances should not have been left, but have been converted into colouring matter. There are two other substances whose presence has not as yet been accounted for, and these are anthraquinone and hydroanthraquinone.

Monoxanthraquinone, isoanthraflavic acid, and anthraflavic acid, when being converted into colouring matter by treating with caustic alkali, cause nascent hydrogen to be liberated, as we have seen. This, acting upon other portions of these same substances, reduces them thus—

$$\underbrace{C_{14} H_8 O_3}_{\text{Oxanthraquinone.}} + H_2 = C_{14} H_8 O_2 + OH_2$$

$$\underbrace{C_{14} H_8 O_4}_{\text{Isoanthraflavic and anthraflavic acid.}} + H_4 = C_{14} H_8 O_2 + 2\ OH_2$$

And part of the anthraquinone thus formed also unites with hydrogen, forming hydroanthraquinone.

The presence of these two substances, then, represents a certain amount of reverse action, and, consequently, loss to the manufacturer. Fortunately, means have been found of almost entirely preventing their formation, and also of ensuring the intermediate products being converted into colouring matter. I shall have to speak of this further on.

I will now refer to the process of making artificial alizarin by means of dichloranthracene in place of anthraquinone.

Sulphuric acid forms two sulpho acids with dichloranthracene, a mono and a di.

To obtain the former, pure dichloranthracene is intimately mixed with concentrated sulphuric acid, warmed up to about 50° C., the mixture being well stirred; this process is continued for about twenty-

four hours. It is then diluted, boiled, and filtered from any undissolved dichloranthracene. This filtrate gelatinises on cooling, and consists chiefly of monosulphodichloranthracenic acid; it is formed thus:—

$$C_{14}H_8Cl_2 + SO_4H_2 = \underbrace{C_{14}H_7(SO_3H)Cl_2}_{\text{Monosulphodichloranthracenic acid.}} + OH_2.$$

On boiling this with an oxidising agent, it yields monosulphanthraquinonic acid.

$$C_{14}H_7(SO_3H)Cl_2 + O_2 = C_{14}H_7(SO_3H)O_2 + Cl_2.$$

And this, when fused with caustic alkali, behaves in the same manner as the acid prepared from anthraquinone, yielding finally, pure alizarin.

If the dichloranthracene be heated more strongly with sulphuric acid, it is converted into the disulphodichloranthracenic acid* thus:—

$$C_{14}H_8Cl_2 + 2SO_4H_2 =$$
$$\underbrace{C_{14}H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}Cl_2}_{\text{Disulphodichloranthracenic acid.}} + 2OH_2$$

An acid remarkable for the fluorescence of its solutions and salts. If the heating with sulphuric acid be increased after the acid is formed, a very remarkable change takes place, sulphurous anhydride and hydrochloric acid being evolved in abundance, disulphanthraquinonic acid being at the same time formed:—

$$C_{14}H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}Cl_2 + 2SO_4H_2 =$$
$$C_{14}H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}O_2 + 2SO_2 + 2HCl$$

This, of course, when fused with alkali, eventually forms anthrapurpurin; and, as some of the disulphanthraquinonate is also formed, a little flavopurpurin is likewise produced.

There is also another reaction which takes place. As dichloranthracene combines with sulphuric acid, water is liberated, so that this acid becomes somewhat diluted. This does not readily form a sulpho acid with the dichloranthracene which has not dissolved, but when heated with it, converts it into anthraquinone.

$$\underbrace{C_{14}H_8Cl_2}_{\text{Dichloranthracene.}} + SO_4H_2 =$$
$$\underbrace{C_{14}H_8O_2}_{\text{Anthraquinone.}} + 2HCl + 2SO_2$$

As the temperature rises, the acid becomes concentrated, and then combines with it, forming chiefly monosulphanthraquinonic acid.

The process of making monosulphanthraquinonic acid from the monosulphodichloranthracenic acid has not been carried out successfully on the large scale, partly owing to the processes of filtration being very difficult to perform. But the preparation of artificial alizarin from the sulpho acids prepared by heating dichloranthracene strongly with sulphuric acid, is a process of very great importance.

As pure alizarin can now be obtained in any quantity, attention has been turned to the preparation of its derivatives. In 1874, I studied the action of bromine upon it, and obtained monobrom alizarin, having the formula $C_{14}H_7BrO_4$.* This compound dyes mordants somewhat similarly to alizarin, the colours being a little redder in shade, but not sufficiently different to make it of technical interest. In 1875, I also obtained a nitroderivative of alizarin by acting on diaceto alizarin with fuming nitric acid.† This substance crystallizes in beautiful orange needles, and has the formula, $C_{14}H_7(NO_2)O_4$. It produces with mordants colours very different from alizarin, giving with alumina brilliant orange, and with iron mordants reddish purple colours. It would be a valuable dying agent if it could be produced by a more easy process.

When treated with reducing agents, such as sodium amalgam, or metallic tin and potash, its blue alkaline solution changes to a clear bright red colour, containing another new derivative, namely amidoalizarin, $C_{14}H_7(NH_2)O_4$. This also dyes mordants, the alumina ones of a purple and the iron ones of a bluish or steel-like colour.

A second, or β nitroalizarin isomeric, with that I produced, has been obtained by Rosenstiehl,‡ and, apparently about the same time, by Caro,§ by submitting dry alizarin to the action of nitrous acid vapours. It is now manufactured in some quantities, and is known as alizarin orange. Like the nitroalizarin previously described, it gives orange colours with alumina mordants. They are, however, much yellower, and not so fine. This nitroalizarin dissolves in dilute alkalies with a purplish crimson colour; but strong alkaline solutions precipitate it, especially caustic soda, and this property affords a means of purifying it. When boiled with metallic tin and caustic potash, it is reduced, becoming blue and then yellowish green s but, on exposure to the air, this solution change; back to bluish green. Schunck and Roemer‖ have just published an account of this reduction product; it is an amidoalizarin isomeric with that just described. In crystallises in deep yellow prismatic needles, and dissolves in potash with a blue colour. It dyes alumina mordants a dull red, and iron mordants a dull grey colour.

A very peculiar result has been obtained by M. Prud'homme¶ by heating a mixture of glycerine, β nitroalizarin, and concentrated sulphuric acid. By this means a colouring matter is obtained which dyes alumina, and especially iron mordants, an indigo blue shade. It crystallises in needles of an almost black colour, but having a coppery reflection. The formula is $C_{17}H_9NO_4$. It is manufactured commercially, but as its colours are fugitive it has not met with much favour.

F. de Lalande** has made the interesting discovery that purpurin, identical with that found in madder, can be obtained by the oxidation of alizarin. He takes a solution of one part of alizarin in eight or ten parts of sulphuric acid, and adds to it one part of arsenic acid or peroxide of manganese, and heats this mixture to a temperature of 150 to

* *Journal Chemical Society*, 1871, p. 15.

* *Journal of the Chemical Society*, 1874, p. 401.
† *Journal of the Chemical Society*, 1876, vol. ii., p. 578, and Deut. Chem. Ges. Ber., 1875, p. 780.
‡ Deut. Chem. Ges. Ber., 1876, 1063.
§ Patent No. 1,229, March 22, 1876.
‖ Deut. Chem. Ges. Ber., 1879, 588.
¶ Bull. Soc. Chem. (2), xxviii, 62—64
** "Jahresbericht," 1874, p. 486.

160° C, until a drop of the fluid mixed with an alkali gives a red colouration. The product is then thrown into water, and the purpurin which precipitates is collected on a filter and well washed.

In this paper I have purposely confined my remarks to the colouring matters and other substances obtained in the manufacture of artificial alizarin, and also to some of the more important derivatives of alizarin; a considerable number of products have, however, been obtained, which are related to anthracene, although this hydro-carbon has not been used in their preparation, such, for example, as anthraflavone from oxybenzoic acid, &c. And, although I do not propose to give an account of these bodies, I wish briefly to refer to some very interesting results which have been obtained by Baeyer and Caro.

These chemists have observed that, when phenol is heated with phthalic acid or anhydride and an excess of sulphuric acid, that two monoxanthraquinones are produced, one identical with that already described, the other being an isomeride of that body. Both of these, however, when fused with caustic alkali, yield alizarin.

By substituting pyrocatechin for phenol in the above process, they succeeded in obtaining alizarin at once. These results, although at present of no practical value, are of considerable scientific interest, and also show us that anthracene is not the only artificial source of alizarin.

From what I have told you this evening, you will see to what an advanced state the chemistry of my subject has arrived, (and yet there is much to be done), and only those who have been interested in the progress of the manufacture, can rightly appreciate the great value of all this research in forwarding the successful and economical production of these colouring matters.

As I have already shown, both of the important colouring matters of madder have now been obtained from anthracene, and not only so, but new products allied to these have also been produced, the most important one being that valuable colouring matter anthrapurpurin; we have also flavopurpurin and the derivatives of alizarin. So that, with these colouring matters, dyers and calico printers are not only able to produce all the various madder styles, but to introduce colours of greater beauty and variety than when employing the natural dye-stuff madder.

LECTURE II.—DELIVERED MAY 22.

Last Thursday week, I brought before you a brief account of the dye-stuff, "madder," and also of the chemical history of its colouring matters, alizarin and purpurin, their artificial production from anthracene, and of the new dyes which are allied to them, &c. I treated the matter, to some extent, from a purely scientific point of view, as I felt it necessary to do so before proceeding to give an account of the practical operations involved in the manufacture of these substances.

To-night I propose bringing before you the history of the technical part of my subject; but before entering into this, I wish to mention that I had the good fortune of being associated with my brother, Mr. T. D. Perkin, in carrying out this manufacture, and to his business habits and skill in devising and erecting new plant, the rapid development and success of this new industry was to a great extent due.* Our works were at Greenford-green, near Harrow, and on the Grand Junction Canal. They were erected in 1857, for the manufacture of the mauve dye, and afterwards also used for the production of various other coal tar colours. I mention this because we were able to employ some of our plant which had fallen into disuse for our preliminary operations, and thus a considerable amount of time was saved. Our manufacturing experiments for the production of artificial alizarin were commenced about the middle of 1869, and the first question which naturally came before us was that of the production of the raw material, "anthracene." At this period anthracene was unknown to the tar distillers, and, consequently, was not a commercial product. Experiments had, therefore, to be made upon its preparation, not only to obtain it, but also to get some rough idea of the amount that could be produced from coal tar, because, unless it were practicable to get it in quantity, artificial alizarin could not successfully compete with madder.

For the purpose of preparing anthracene for my experiments in 1855, I had employed coal-tar pitch, and distilled it in iron pots. I, therefore, naturally selected pitch as the source of anthracene, and having a number of iron retorts ready for use, many tons were distilled. From the amount of anthracene we obtained in this manner, we felt assured there was no reason to fear there would be any lack of raw material.

When distilling pitch, we found it generally best not to allow the very last portions of the distillate to mix with the earlier ones, as they are sticky, and contain little, if any, anthracene. Sometimes we re-distilled the distillate; this improved it considerably. (Distillation of pitch in pitch ovens destroys most of the anthracene.) The oily distillate, on being allowed to stand for some days, deposits the anthracene; this we separated, by draining the products in canvas bags, and then pressing out as much of the remaining oil as possible with a screw press. In July, we set up our first hydraulic press for this purpose. The crude anthracene was then washed with coal-tar naphtha, and afterwards distilled. The apparatus for distilling consisted of two retorts, set side by side, connected to each other by a large bent iron pipe, one retort being used as a still, the other acting as a receiver. The connecting-pipe was kept hot, to prevent the anthracene from blocking it by condensing. The distilled anthracene was partly in the form of a hard, yellow, crystalline mass, and partly in the form of a crystalline powder.

We obtained by this means about $\frac{3}{4}$ to 1 per cent. of pure anthracene from the pitch we employed. During the time we were carrying on these experiments we asked some large tar distillers, Messrs. Blott, of Poplar, London, to collect the last runnings of their tar stills, and set them aside to cool. These deposited considerable quantities of anthracene, which was collected in canvas bags, and it was soon found, that by this means, large quantities of anthracene could be obtained. Messrs. Blott then commenced to prepare this substance in quantity,†

* Our firm was known as Perkin and Sons.

† July, 1869.

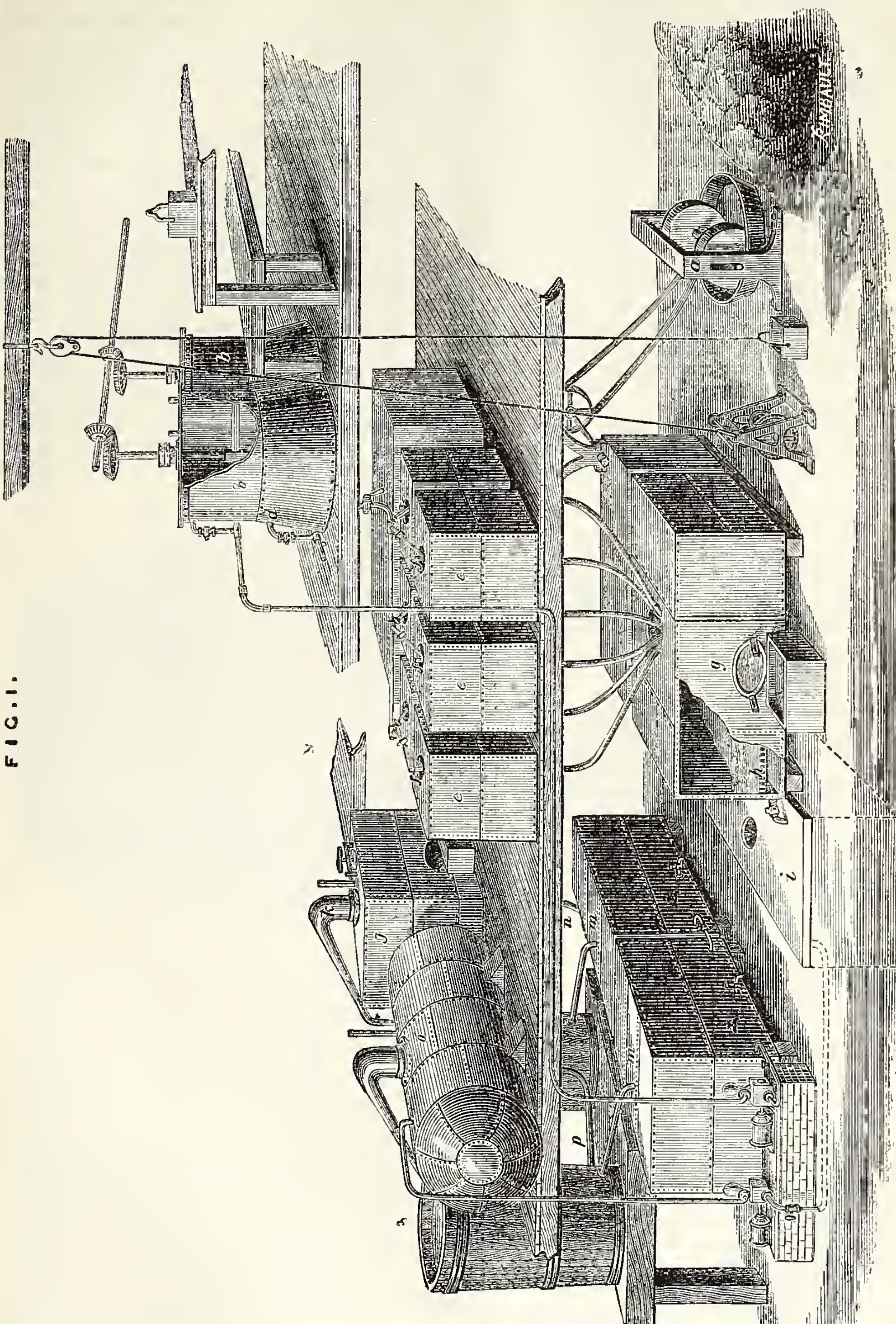


FIG. 1.

and to supply us with it. Other tar distilleries were then communicated with, in fact, nearly all the tar distillers in the United Kingdom were either visited or written to on the subject, and the result was that, in a short time, such quantities of anthracene came in that it was unnecessary for us to continue to distil pitch.

The anthracene obtained from the tar distillers was sent out in casks, and was in a thick pasty condition. It was pressed in hydraulic presses between thick linen sheets, in the same manner as paraffin is pressed when being purified, and was thus obtained in solid cakes, weighing about one-fourth of the unpressed product. Most of the tar distillers now press their anthracene before sending it into the market. The anthracene supplied at first was usually of a very good quality, much better than afterwards, when it was found to be an important product, because the distillers then endeavoured to extract all they could from their tar, and thus many other products were separated with it.

The pressed anthracene was at first purified, as above, with coal-tar naphtha, and then distilled, but it was found to be still far from pure; this was a great drawback, because, when converting it into anthraquinone, by oxidation with potassic bichromate and sulphuric acid, in the way we then conducted the process, a large quantity of the oxidising mixture was used up on the worthless impurities as well as on the anthracene, thus adding greatly to the expense of the anthraquinone, and not only so, but rendering the purification of that substance more troublesome.

After making a number of experiments with different solvents, which were only partially successful in removing the impurities of the anthracene, I thought that, by distilling it with a caustic alkali, some good might be effected, as all substances of a phenolic character would be removed, and some of the high boiling and less stable products might be charred. In this I was not disappointed. A quantity of anthracene which had been purified with naphtha and distilled, was redistilled in a glass retort with solid caustic potash. The distillate was considerably less in weight than the anthracene taken, and in the retort there was a large quantity of a black carbonaceous residue. Although still not pure, the anthracene was immensely improved in quality, and, with but little treatment with solvents, yielded a chemically pure product, crystallising in a most beautiful manner, superior to anything I had ever seen before.

The process was next tried on the large scale, caustic soda being employed in place of caustic potash, but I was surprised to find that no purification of any consequence was effected; on repeating it, however, with caustic potash, the same result was obtained as that in the laboratory.

After experimentally proving that anthracene is not destroyed when distilled with potash, this process was adopted on the large scale.

In purifying anthracene with coal-tar naphtha, a loss of anthracene was found to take place, on account of its solubility in that fluid. We found, however, that, by using petroleum spirit, this loss was, to a great extent, avoided; therefore, the use of naphtha was discarded.

After many experiments, the purification of crude anthracene was conducted in the following manner.

The first operation, viz., the treatment with petroleum spirit, was conducted in a large, separate building. The internal arrangements of this were practically the same as represented in Fig. 1 (p. 583).

The crude anthracene was first thoroughly ground under the edge-runners, *a*, which made most of the ordinary qualities of pressed anthracene into a very stiff, pasty mass. The ground anthracene was then put into boxes, and hoisted to the top floor of the building by means of a windlass. It was then introduced into the large iron cylindrical vessels, *b b*, which had been previously half-filled with petroleum spirit, and the agitator, *c*, also set in motion. About 1,500 to 1,800 lbs. of crude anthracene, and about 300 gallons of petroleum, were used in each operation, the proportion of petroleum, however, being varied according to the quality of the anthracene.

Steam was then turned on to the steam jacket, *d*, with which the cylinder is provided, until the petroleum nearly boiled, the man-hole being kept loosely covered, to avoid evaporation. The stirring was continued for an hour or two, after which the product was run into cooling tanks, *e*. These were not very large, and kept apart, so that the air might freely circulate around them. The principal object of the cooling was to allow any anthracene which had dissolved in the petroleum spirit to crystallise out. When cold, the wooden plugs, *f*, which close the outlets of these tanks were removed and their contents run out into the filter tank, *g*. The filter consists of a perforated wooden floor, covered with coarse canvas, *h*. As the petroleum, charged with impurities drains away, it was received in a large tank sunk in the ground, *i*. The anthracene on the filter was afterwards washed by pouring over it a little clean petroleum spirit.

When thoroughly drained, the anthracene was removed to the tank, *j*, provided with a still head, *k*, connected to a worm tub, *l*; some water was then added, and steam blown through the mixture, to volatilise the petroleum, which afterwards condenses in the worm, and runs into the tank, *m*.

In the bottom of the tank, *j*, there was a large tap connected, with a pipe *n*. When the operation was finished, this was opened to allow the water to flow out, and as this usually carried anthracene with it, it was passed through canvas bags. The front manhole was then opened, and the anthracene removed and placed in dry casks to further drain. In this operation, average qualities of anthracene usually lost about 30 per cent. of impurities.

The dirty petroleum in the tank, *i*, was pumped into the still, *o*, and distilled by blowing steam through it; it then flowed into the tanks, *m*, and after the water which has condensed with it was run off sufficiently by the taps near the bottom of the tanks, so that only petroleum flowed from the two little test taps placed higher up, it was pumped into the cylinders, B B, and used for a fresh operation, and thus it was used over and over again.

The residue in the still, *o*, was a dirty, thick, oily product mixed with water; it was run out at the pipe, *p*, into tanks, and on cooling became a semi-solid mass. This product was used as fuel under

evaporating pans. For this purpose it was kept fluid, by being warmed in a boiler, it was then run through a pipe into a special jet supplied with steam, which converted it into spray. This was kept ignited under the pans by means of a small coke fire.

The next operation consisted in distilling the anthracene, thus far purified with caustic potash. For this purpose ordinary Montreal potash was used. This was usually found to contain considerable quantities of caustic potash, and answered the purpose perfectly. We found it necessary to use some caustic lime with it, otherwise the residue left in the retorts caked so hard that it was only with great difficulty that it could be removed.

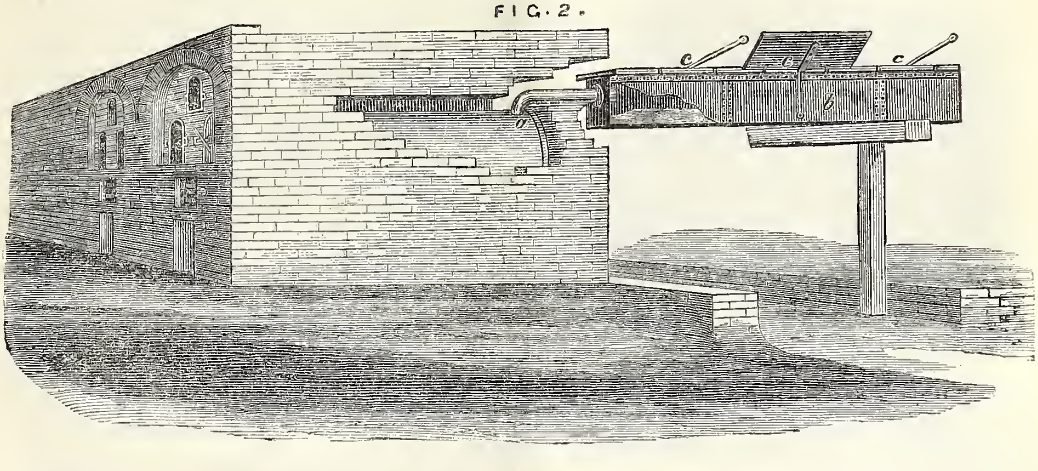
The proportions used were usually in the ratio of 100 parts of washed anthracene, 30 parts potash, and 6 parts ground lime. These substances were thoroughly ground under edge runners, and introduced into iron retorts and distilled.

When we first distilled the anthracene with potash, we employed retorts with the outlets at the back bolted on, but we found it impossible to get joints to stand the constantly repeated heatings and coolings of the apparatus. We, therefore, had the necks cast on the retorts, as in Fig. 2 at *a*. It was also found necessary to keep the mouths of the retorts well over the dead plates, otherwise anthracene condensed on the retort door.

For some time we used large iron tanks as condensers, two or three retorts distilling into each, but as considerable quantities of hydrogen gas were given off, the operation of cleaning them out was dangerous, because, as the air mixed with the hydrogen, it became an explosive mixture, and if any part of the retorts had not cooled down sufficiently, this would be ignited; in fact, it was owing to an accident of this kind, that we first noticed the evolution of hydrogen. Afterwards we made experiments to see how small a receptacle could be used, and at last found that reservoirs of the shape and construction seen in the diagram answered perfectly. They consisted of iron troughs, as seen at *b*, fitted to the retort neck. The further end of the receiver was closed with a loosely-fitting piece of wood. The top consisted of loose iron lids, hinged on one side of the trough, and provided with long iron handles, *c*, *c*, *c*, so that they could be easily opened or closed.

Before the distillation was commenced, these lids were luted down, but this was scarcely necessary,

FIG. 2.



as the sublimed anthracene soon stopped up the crevices. The hydrogen escaped at the back end of the trough. The retorts were set on fire lumps, to prevent their burning out. The distillation was commenced in the morning, after the previous day's residues had been cleaned out from the retorts, and they had been re-charged.

Before the receivers were emptied, the lids were opened from below, so that any permanent gas might escape, and then the anthracene removed. This was found to be partly in the form of very pale primrose, yellow crystalline cakes, and partly as a light sublimate. As it contained some water locked up in its interstices, it was ground under-edge runners and then dried. The black carbonaceous residue left in the retorts, when heaped together, easily catches fire, and continues to burn for a very long time. The potash was recovered from this residue, causticised, and again used.

When commencing the manufacture of artificial alizarin, we employed the process described in my first patent, in which anthraquinone is used. By this method we prepared large quantities of colouring matter. My second process, however, was found, especially at that date, to possess considerable advantages over the first. In this, it will be remembered, dichloranthracene is used, and therefore as soon as the technical difficulties were mastered, we employed it in preference to the first, though sometimes we manufactured by both.

As most of the colouring matter manufactured by us was prepared by the dichloranthracene process, I have thought it best to describe it first, afterwards returning to our experiences with the anthraquinone method.

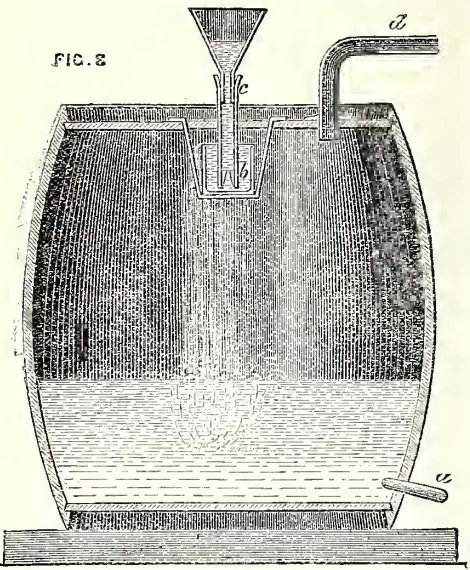
A large number of experiments were made upon the preparation of dichloranthracene, such as passing chlorine over anthracene suspended in solvents; or over anthracene which had been purified with petroleum spirit or bisulphide of carbon and then distilled; or anthracene which had been distilled with caustic potash.

The result of these experiments was, that it was found that the best process consisted in passing

chlorine over anthracene which had been purified by distillation with potash; as, by this means, a beautiful product was obtained, which could be easily purified; whereas, anthracene which had not been distilled with potash usually gave a confusedly crystallised, sticky mass, very difficult to deal with.

As it was very important to produce colouring matter with the least possible delay, the manufacture of chlorine for the preparation of dichloranthracene was a matter requiring a good deal of consideration; because, if plant had to be erected, to prepare it in the ordinary method from black oxide of manganese, a great deal of time would have been lost. We, therefore, thought that, until the ordinary plant could be erected, we might make it expeditiously by decomposing chloride of lime with hydrochloric acid; and we found this to answer our purpose. The apparatus we used was of a very simple nature. It consisted of a large well pitched wooden cask (Fig. 3). A hole

FIG. 3



was made near the bottom, and fitted with a plug, a, so that it could be easily emptied. In the top a square hole was cut, from which an earthenware jar was suspended by means of leaden straps, b. The square hole was closed with a perforated piece of wood, through which a leaden pipe, c, was placed, reaching to the bottom of the earthen jar, the bottom of the pipe was partly cut away, so that liquid could run freely through it. A funnel was also fitted to the top of the pipe. Through another perforation in the top of the cask, a bent leaden pipe, d, was fitted to serve as a delivery tube. This passed to a stoneware Woulfe's bottle. In using this apparatus, hydrochloric acid was poured into the cask. The necessary amount of chloride of lime was then mixed with water in a tub, so as to form a creamy fluid. This was then passed through the funnel into the hydrochloric acid by degrees, and according as the chlorine was wanted in a rapid or slow current, the chloride of lime was added quickly or slowly. This process does not work well if the chloride of lime is placed in the cask, and the hydrochloric acid added, on account of the greater density of the chloride of lime. One advantage of this method of generating chlorine is that the amount can be easily regulated by the chloride of lime used. Of course, this is an expensive method of preparing chlorine, and we always intended putting down proper plant, with Weldon's arrangement for recovering the manganese; but our attention was then so taken up with other matters, that we kept putting it off, and continued to use chloride of lime until we gave up manufacturing. I should imagine this was the first instance of chlorine being prepared in large quantities in wooden tubs, and I have described it, as it might be useful to others who want a supply of this gas without loss of time.

For treating the anthracene with chlorine, leaden chambers were used, technically called "chlorine ovens." They were about 10 ft. long, 4 ft. 6 in. wide, and 1 ft. 6 in. deep in the centre. Fig. 4 (see page 588) is a representation of a pair of these ovens. From the section, it will be seen that the bottoms are flat until within about 1 ft. 6 in. of the end. They then gradually slope up about 6 in., to the manholes at the ends, a a. The doors of these manholes are slabs of wood covered with lead, and held in their place by means of a cross-bar and screw. The lugs are connected with an iron frame, over which the lead is beaten. In the centre of the top are other openings for charging the ovens, $d\,d$, and b in section. They are provided with lids, made air-tight by means of hydraulic joints. The channels in these joints, however, were not filled with water, but by an impurity obtained in the manufacture, called "chlorine oils." At each end of these ovens, two lead pipes are inserted, one for the inlet of chlorine, and the other for the escape of hydrochloric acid and unused chlorine. These pipes are made to project into the ovens, to prevent the action of any "drip," which might otherwise injure the top of the oven. The top is strengthened by cross pieces of timber, fastened with leaden straps. The ovens were usually made of 20-lb. lead. The luting for the end manholes was made of china clay and chlorine oils.

When first made, these ovens were supported on solid brickwork, and it was found that, by passing a good current of chlorine over the anthracene, sufficient heat was, by the chemical action, evolved to complete the process; if, however, the temperature was allowed to fall from an interrupted or slow supply of chlorine, the product partially crystallised, and the temperature could not be got up again sufficiently. The anthracene was, therefore, imperfectly chlorinated. To avoid this, a steam chamber was formed in the brickwork, c, seen by the dotted line, and covered by an iron plate, on which the oven rested, and in this way the temperature was always sufficiently maintained.

The hydrochloric acid gas which was formed in this operation, was condensed in coke towers, and the acid used again. The reaction may be written thus:—

$$\underbrace{C_{14}H_{10}}_{\text{Anthracene.}} + 4\,Cl = \underbrace{C_{14}H_{8}Cl_{2}}_{\text{Dichloranthracene.}} + 2\,H\,Cl.$$

It is, however, probably much more complicated.

Chlorine when acting upon anthracene first forms a dichloride :—

$$C_{14} H_{10} + Cl_2 = C_{14}H_{10}, Cl_2.$$

This substance is extremely unstable, and unless the temperature be kept near 0° C., decomposes as quickly as it forms, yielding monochloranthracene :—

$$C_{14} H_{10} Cl_2 = \underbrace{C_{14} H_9 Cl}_{\text{Monochloranthracene.}} + H Cl.$$

This substance, when meeting with fresh chlorine, is believed to combine directly, and form a dichloride of monochloranthracene :—

$$C_{14} H_9 Cl + Cl_2 = \underbrace{C_{14} H_9 Cl Cl_2}_{\text{Dichloride of monochloranthracene.}}$$

and, lastly, this, on decomposing. to yield dichloranthracene

$$C_{14} H_9 Cl, Cl_2 = \underbrace{C_{14} H_8 Cl_2}_{\text{Dichloranthracene.}} + H Cl.$$

Towards the end of the operation of chlorinating anthracene the chlorine is not all absorbed, and escapes into the air from the coke towers. This was not only a nuisance but also a loss. To avoid this the ovens were put up in pairs, and connected with a leaden pipe ; both were charged with anthracene, but only one chlorinated. Any unused chlorine passing away with the hydrochloric acid over the anthracene in the second oven was thus absorbed. The next day the anthracene in the second oven was chlorinated, and the gases passed over the other one, which had been re-charged with anthracene.

The charge for each oven was usually about 400 lbs of anthracene which had been distilled with potash, and of between 40 and 50 per cent. quality. On passing the chlorine gas into the charged ovens, the anthracene gets dark in colour and fuses,* hydrochloric acid being evolved in abundance. After a time, this fluid product begins to deposit crystals, and soon becomes a semi-solid mass. The operation occupies about five or six hours. When finished, the top man-holes were removed, and a light wooden flue, *b*, placed over them and connected with the opening into the chimney shaft, *e*, the end man-holes were then opened, and in a short time the excess of hydrochloric acid and chlorine in the ovens was drawn out. The crude dichloranthracene, which covers the bottom of the oven as a crystalline cake, was loosened by a wooden tool, and then drawn out with a wooden hoe into some convenient vessel, as *f*. When broken up, the pieces of dichloranthracene appear as a mass of beautiful bright yellow interlaced needles.

This product was next broken up with a wooden beater in tubs containing dilute caustic soda (it must not be ground, however), to remove adhering hydrochloric acid. It was then separated from the alkaline solution and pressed between linen cloths in the hydraulic press, when a dark, thick, oily product separated out. This consists principally of chlorinated phenanthrene, holding in solution a little dichloranthracene and anthracene, and was called "chlorine oils." I shall have occasion to refer to these again presently.

After pressure, the dichloranthracene was obtained in hard yellow crystalline cakes, but not sufficiently pure for use. It was again broken, and allowed to soak in coal-tar naphtha* for some time, and pressed; this operation was again repeated. The adhering naphtha was then recovered by blowing steam through the product.

The dichloranthracene thus purified was afterwards placed on trays, and dried in a drying-room, and was then ready for the next process. It contains about 84 per cent. pure dichloranthracene.

The chlorine oils, and also the residue left after distilling the naphtha used for washing the dichloranthracene contains a certain amount of dichloranthracene and anthracene. This separates out to a considerable extent, if the oils be cooled with ice, but the product is then so thick that it cannot be filtered or pressed.†

Experiments were made on distilling them alone, but owing to the copious evolution of hydrochloric acid, and the frothing of the product, it was not found practicable to treat them in this manner ; but by previously mixing an excess of ground lime, and then distilling in iron retorts, a considerable amount of solid product came over containing about 25 per cent. anthracene, which only required to be treated with petroleum spirit to fit it for use. It is believed that the anthracene represents that which had not been chlorinated, the dichloranthracene being decomposed by distillation with lime.

The next process consists in converting the dichloranthracene into the sulpho acids of anthraquinone by treating it with ordinary concentrated sulphuric acid, and the ease with which this is effected was originally one of the advantages of the use of dichloranthracene over anthroquinone.

For this process iron pots were used, as they were found to answer nearly as well as glass, and, of course, were more manageable. As hydrochloric and sulphurous acids are evolved in quantity in the operation, special arrangements had to be made for conducting these away, and condensing them. The kind of apparatus used is shown in Fig. 5 (p. 589). It consists of a row of cast iron pots, *a a*, capable of holding about 30 gallons. These are cast with half-covers, in which there is an opening for the escape of the acid vapours.

Earthenware pipes, *b*, *b*, *b*, are luted into these openings and connected with a large main, *c*, which leads to arrangements filled with coke, and supplied with water for the condensation of the hydrochloric and sulphurous acids.

The pots are set in brickwork, and heated by a fire, the upper part being also surrounded by brickwork to prevent loss of heat, the open part of the pot is covered with a lid, *d*, made of 20-lb. lead, which can be removed when they are emptied. In the centre of this lid an oblong hole, about 6 in. by 8 in., is cut, for the introduction of the dichloranthracene. This is covered by a piece of lead, *e*. There are also two small round holes in the lid; one for the introduction of a thermometer,

* This is due to the chlorination of the impurities, the dichloranthracene being formed afterwards.

* Petroleum spirit does not answer well for this purpose.

† Perhaps a filter press might be used for this purpose successfully.

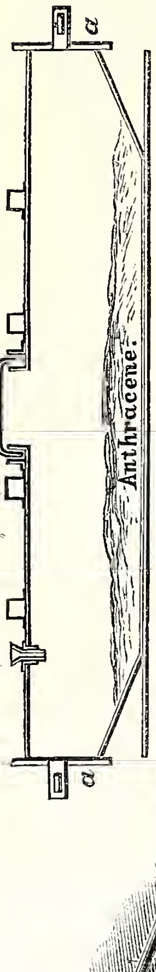
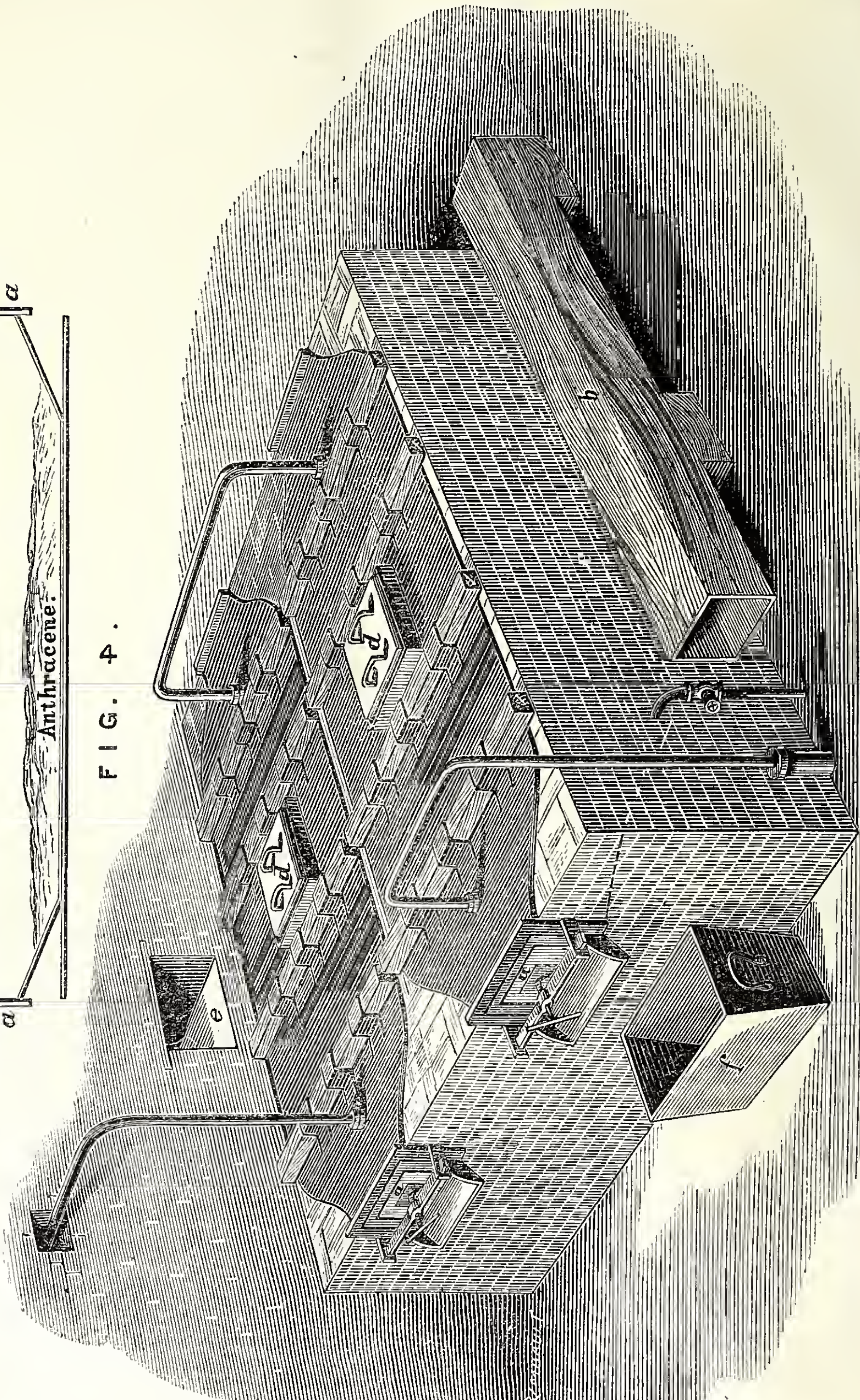


FIG. 4.



f, the other as a testing-hole, and fitted with a wooden plug, *g*.

These pots were charged with 350 lbs. of sulphuric acid. This was then heated up to about 140° to 160°, and the dichloranthracene gradually added in small shovelfulls at a time, hydrochloric and sulphurous acid being evolved after each addition, causing frothing, especially if the dichloranthracene be of a low quality, or damp. The charge used was usually 70 lbs.

After all the dichloranthracene had been added, the temperature was gradually raised until it reached about 260° C., and then continued at this until a sample, taken out by a glass rod and diluted with water, formed a nearly clear solution, devoid of fluorescence. The fire was then drawn, and the product left to cool down until the next morning. It was then found to be still warm, of a brown colour, and the consistency of treacle. The lids being lifted off, it was ladled into copper pails, and carried away to be neutralised with lime.

In this process the following reactions take place:—First, disulphodichloranthracenic acid is formed by the union of the sulphuric acid with the dichloranthracene; and, secondly, this product is oxidised by the excess of sulphuric acid forming disulphanthraquinonic acid. These, however, are not the only changes. Anthraquinone is also formed, which becomes converted chiefly into monsulphanthraquinonic acid; some of it also sublimes, and then condenses in the earthenware main, through which the acid vapours pass.

When fuming sulphuric acid is used in place of the ordinary, no anthraquinone or monosulphanthraquinonic acids are formed.

Pure dichloranthracene, when treated with Nordhausen sulphuric acid, gives the theoretical yield of disulphanthraquinonic acid.

We see, then, that when ordinary sulphuric acid acts upon dichloranthracene, that we get a mixture of the mono and disulpho acids of anthraquinone; the latter, however, greatly preponderates. The product also contains a considerable quantity of free sulphuric acid, which it is necessary to remove; this is done by means of slaked lime, with which it forms a nearly insoluble sulphate, and at the same time neutralises the sulpho-acids, forming soluble lime salts; we conducted this operation in the following manner:—

The crude sulpho acids from the iron pots were diluted in a large wooden tank (*a*, Fig. 6, p. 590), and boiled by blowing steam into it. Slacked lime in a wet state was then added by degrees, with constant stirring, until the product was neutralised. Wooden tubs, with mechanical stirrers, were afterwards substituted for the tanks, but by using Korting's steam jet air injectors, all stirring arrangements may be dispensed with.

Tho neutral product was then run into the vacuum filters, *b*, to separate the sulphate of lime, the clear filtrate passing into the exhausted receivers. The filters consisted of large shallow wooden tanks, on the bottom of which bricks were laid about three inches apart, so as to form channels, and on the top of these some moro bricks, placed side by side so as to form a floor. A layer of about three inches of small pebbles was spread upon this,

FIG. 5.

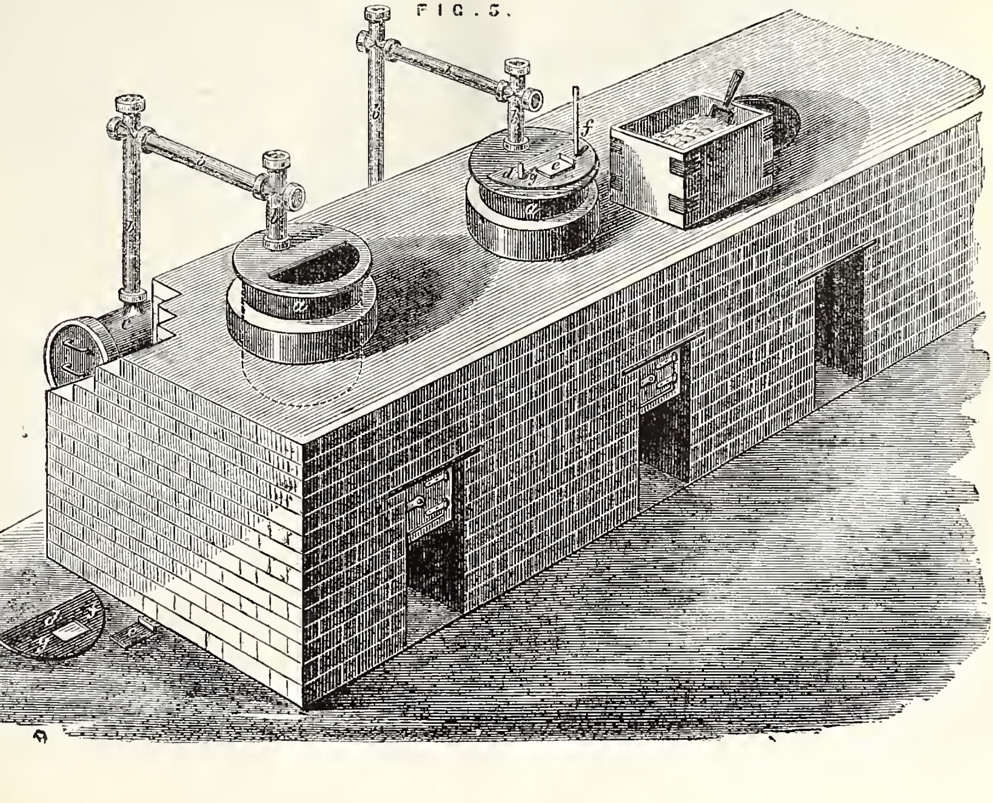
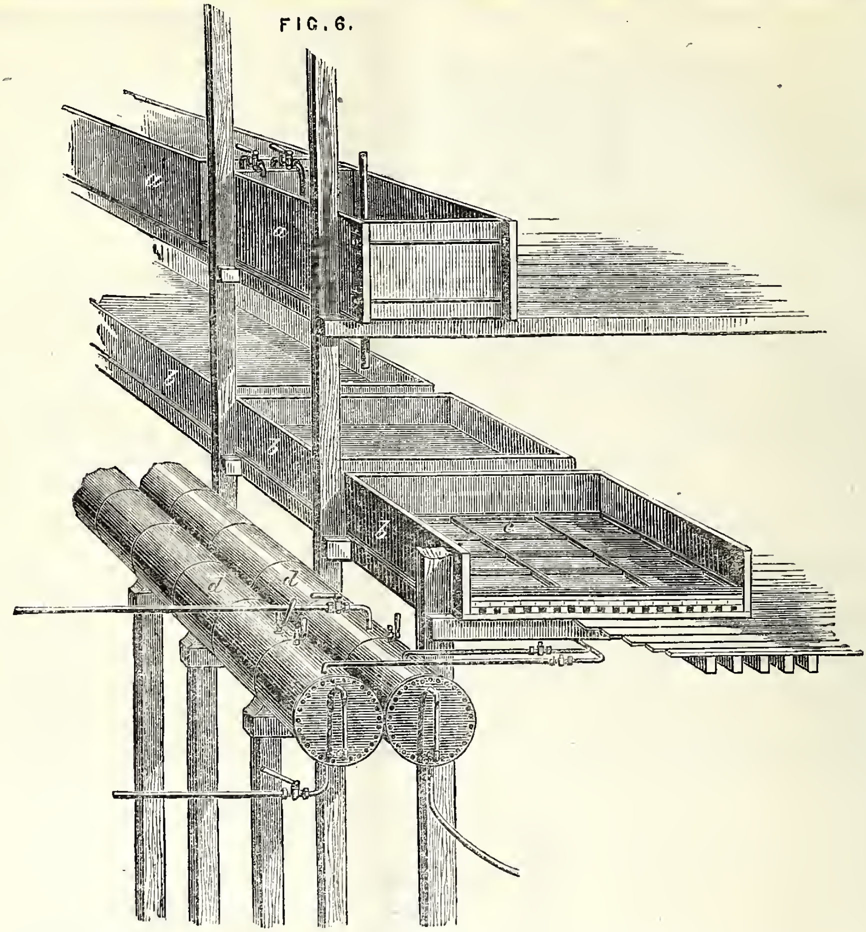


FIG. 6.



and then about three inches of washed sand. This filtering medium was protected by a coarse canvas, kept in its place by a wooden framing, *c*.

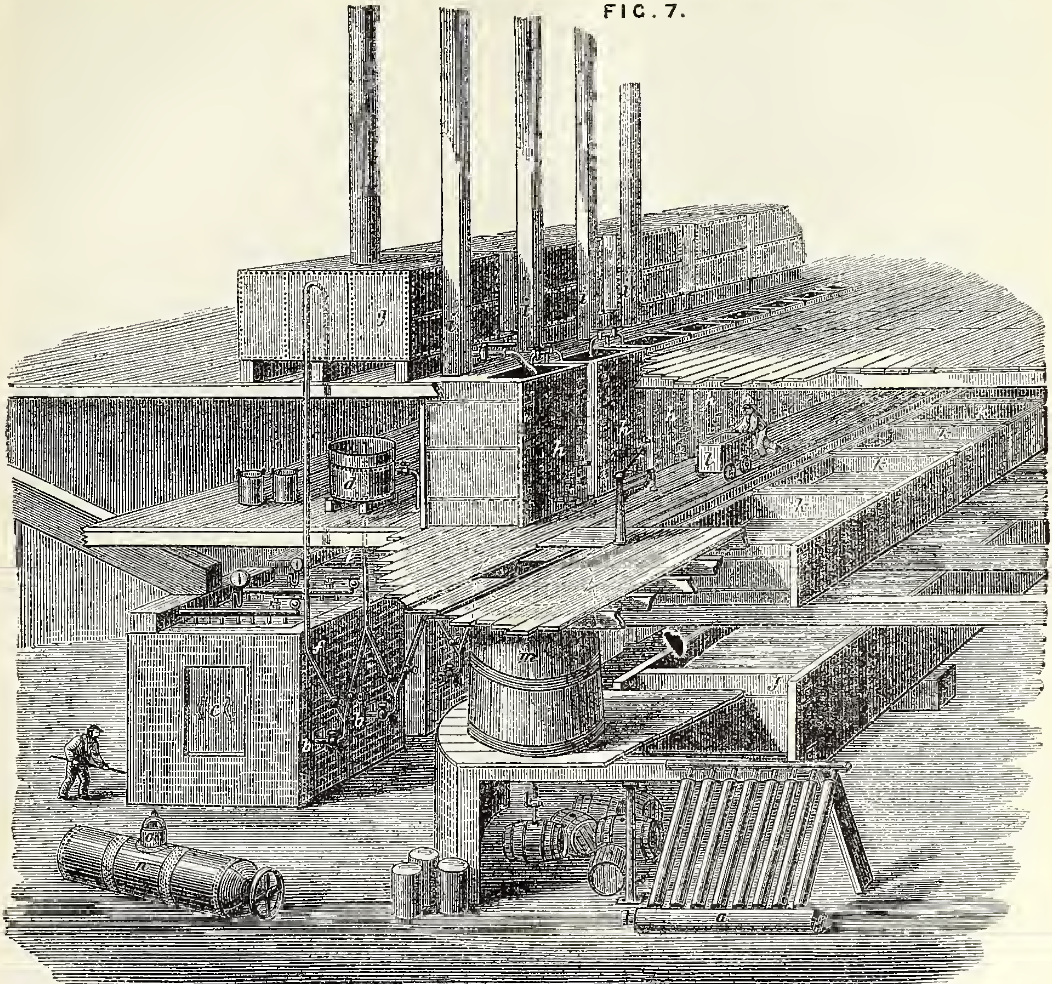
Two iron reservoirs, *d d*, in which a vacuum could be produced by means of an air pump, were connected with these filters, and so arranged with stopcocks that the filtrate might be passed either into the one or the other. One receiver was kept for the first, and, therefore, the strong filtrate and the first washings of the sulphate of lime. These were made with weak liquors from a previous operation. The further washings were made with boiling water, and were drawn into the second receiver. To get all the useful product out of the sulphate of lime, it was necessary to remove it after it had been well washed, boil it with water, and again pour it into the filter. It should always be tested before it is thrown away. A great number of these filters were arranged side by side.

The strong lime salts of the sulpho acids in the first receiver, thus obtained, were concentrated in iron pans heated either over a fire or by steam, until they contain about 15 per cent. of lime salts. Soda crystals (sodic carbonate) were then added in sufficient quantity to precipitate all the lime as carbonate, and thus to produce sodic salts of the sulpho acids. These were syphoned off from the carbonate of lime, and concentrated until they contained about 30 per cent. of sodic salts.

This product, which is technically called "soda salt," consists of at least three compounds, by far the principal one being the β disulphanthraquinonate, which yields anthrapurpurin. On standing, the α disulphanthraquinonate separates out with some of the β. The third salt is the sodic salt of monosulphanthraquinonic acid; but, curiously, this salt, which, when pure, is difficultly soluble in water, remains in solution. There is undoubtedly a small quantity of other salts present, some of which are probably derived from sulpho acids of the impurities of the dichloranthracene, but are of no interest to the colour maker. The three salts just mentioned are also formed when anthraquinone is used instead of dichloranthracene. They are sometimes separated, so that the different colouring matters they produce may be obtained in a more or less pure state.

The next operation consists in the conversion of the product just described, and called "soda salt," into colouring matter. This, it will be remembered, is effected by heating it strongly with caustic alkali. This operation we found difficult to perform on the large scale. First of all, it was necessary to keep the heating within certain limits. If too

FIG. 7.



high a temperature were employed, the product was destroyed, if too low, the colouring matter was not formed; or only partially, and, consequently, a small yield resulted.

In the laboratory, the experiments on this subject were performed in an air bath, the products being heated in metallic dishes, a mixture of "soda salt" in a dry state with a saturated solution of the alkali being taken, caustic potash, caustic soda, and mixtures of these alkalies being used, and it was considered that caustic potash gave, on the small scale, the best yield of colouring matter.

A mixture of caustic alkali and "soda salt," when heated to about 180° C., soon changes in colour; becoming blue, violet, and then appearing as a black mass. As the water evaporates, it also becomes pasty. On testing this, it is found to have decomposed so far as to form sulphoxyanthaquinonic acid. To complete the reaction, the treating has to be continued for a considerable time.

To carry this process out, very many experiments were made, and often with only partial success. One method we tried consisted in employing a long chamber, heated with flues to the requisite temperature, and arranged on the same principle as the ovens used for the continuous baking of fancy biscuits. It was hoped that by introducing shallow iron trays, with the mixture of soda salt and alkali in thin layers, and gradually working them forward to the other end of the oven, that by the time they had arrived there the decomposition would be complete, and thus a continuous method might be established.

This succeeded in a measure, but the time required to keep the mixture in the oven was too long to make it work continuously; moreover, it was found difficult to keep the temperature sufficiently uniform, and local overheating at times occurred, destroying the product.

Another apparatus we tried consisted of a large wrought-iron cylinder, which was made to revolve inside a second, but fixed, cylinder of thick cast-iron, sufficiently large to allow of an air space of several inches between it and the interior cylinder. This was heated so as to form a hot-air chamber' the temperature being carefully regulated and

observed with a thermometer. The axis of the revolving cylinder was hollow, and perforated with small holes, so that the steam, evolved from the mixture of caustic alkali and soda salt with which it was charged, could freely escape. In this arrangement, the heating was very satisfactory; but the operation took a considerable time, especially if the charge were large. Iron cannon balls were afterwards introduced, to keep the mass well mixed; but, curiously, they did not answer the desired purpose, as they became coated to such an extent with the alkaline mixture that, when the operation was over, they were found to be three or four times as large as when put in. Anthraquinone was found to sublime from this apparatus, and in a smaller one, which was overheated, anthracene was obtained.

This apparatus, although a considerable improvement, was not perfect, a good deal of sulphoxyanthraquinonic acid being often found in the product. However, some considerable quantity of colouring matter was manufactured in it.

Experiments were then made in closed iron tubes, with the products mixed with water. It was assumed that, if an excess of alkali were used, and a sufficiently high temperature, that the presence of water would not interfere with the result. Curiously, this was found not to be true, or only partially so, and it was found that, if the caustic alkali and soda salt were in a considerably diluted condition, very little colouring matter was formed; the mixture, instead of becoming violet, was of a brown, or chocolate colour, and contained, as we now know, chiefly intermediate products, such as isoanthraflavic acid. On using less water, however, so that the mixture would contain about 25 per cent., or more, of caustic alkali, colouring matter was readily formed.

After experimenting for some time in closed iron tubes, capable of holding ten or fifteen gallons, some larger apparatus was set up. As it was necessary that this should bear a very considerable pressure, we selected sections of Howard's patent safety boilers, which were made of 10-in. drawn iron tubes, as shown in Fig. 7 (p. 591), at *a*. At the end of the horizontal tube of this arrangement, there is a hole, about four inches in diameter, fitted with a cap, fastened on with screws and made tight with a vulcanised washer. This hole was used for cleaning out the apparatus. At the other end there is a smaller hole, into which a pipe was screwed, and connected with the necessary stop valves, and pipes as seen at *b*, where the apparatus is shown in a complete state. It was charged and discharged through this aperture. At the top it is provided with a pressure gauge, safety valve, and steam cock.

To heat these "pressure tubes," as they were technically termed, we employed a hot-air chamber, in which flues passed underneath and at the sides. A thermometer was suspended through a hole in this chamber, and in case of the temperature rising too high, iron doors in the side were provided, which could be opened so as to quickly admit cold air, as seen at *c*.

The pressure tubes were charged by gravitation from the floor above, and when the operation was completed, their contents were forced up, by the pressure of steam in them, into iron tanks on the top floor of the building, so that all succeeding operations could be performed by gravitation. This will be better understood by referring to the figure, *d*, is an iron pan with a steam jacket, and connected with the pressure tubes by the pipe, *e*. A wooden plug was inserted into the mouth of this, and the required amount of caustic soda, 70 per cent. quality, dissolved; 700 lbs. weight was usually employed. 1,300 lbs. of a concentrated solution of the soda salt was then added, and well mixed. On opening the valves between this pan and the pressure tubes, and the steam cock on the top of them, and then withdrawing the wooden plug, the charge ran quickly in. A little water or caustic soda was afterwards run in from the iron pan to rinse out the tubes. The valves were then closed, and the chamber heated. The temperature was kept up at about 180° C., for twenty-four hours. A small cock was provided, from which samples could be drawn, and the progress of the operation watched. When finished, the fire was drawn, and the valves in the pipe, *f*, leading to the iron tanks, *g*, on the top floor of the building, cautiously opened. The contents of the pressure tubes then rushed up with great force into these tanks; to these funnels were fitted to conduct the steam through the roof.

The product thus obtained is an intense purple fluid, becoming thick on cooling. It consists chiefly of colouring matter, in combination with soda, of sodic sulphite, and a large quantity of caustic soda. To separate the colouring matter from this purple solution, it is first diluted, and then acidified.

We performed this operation in large wooden tanks, lined with lead, and called "precipitating tanks," lettered *h*; these were provided with steam pipes; three cocks were also inserted into the front sides of them. A quantity of sulphuric acid being first diluted in these tanks, the purple solution, when gradually run in, becomes orange in colour, owing to the separation of the artificial alizarin as a yellow precipitate; it also froths up, from the evolution of sulphurous acid, which was carried into the atmosphere by means of the wooden funnels, *i*. If too little acid had been put into the tank, some more was afterwards added.

When the operation is thus far completed, the steam should be turned on, and the product in the tanks well boiled for about an hour, the object being to make the colouring matter more granular than it is when freshly precipitated, so that the next operation may be facilitated.

After being allowed to cool and settle during the night, the yellow supernatant liquor* can be run off from one of the side cocks. For these liquors we provided large tanks on the ground floor, shown at *j*; some water was then run into the precipitating tanks, and then their contents were allowed to flow out on to the filters, *k*, on the first floor.

These "colour filters," as they were termed, were fitted up in a similar manner to those employed in filtering the lime salt of the sulpho acids of anthraquinone, and were also provided with an exhausted receiver, so that the colouring matter could be washed rapidly. As the first drainings always

* Herr Glaser has separated from these an acid which has been examined by Graebe and found to consist of a sulpho acid of alizarin. Deut. Chem. Ges. Ber., 1879, p. 571.

passed quickly through the filters, they were run into the tanks on the ground floor.

The object of these tanks was that any colouring matter which might have run away mechanically, or separated out on the further cooling of the liquors, would be saved. These tanks were emptied, when necessary, to within about a foot of the bottom, the colouring matter being removed from time to time, when sufficient has accumulated to make it worth the trouble. But to return to the colouring matters on the filters. To fit it for the market, it must be repeatedly washed until nearly perfectly free from saline matter, and neutral to test paper. It is then allowed to drain for some time and afterwards removed to the stock tub.

As we collected the artificial alizarin from the filters, we used to transfer it to a truck, *l*, capable of holding several hundred weight of this product, and running on rails. It was weighed before being filled, and again afterwards. It was then wheeled over the large stock tub, *m*, capable of holding several tons, and emptied into it by withdrawing a plug. It was then again re-weighed, filled, weighed, and emptied, and this process continued until the stock tub was sufficiently full. The sum of the weight of the colouring matter from the truck gave the amount stocked.

The colouring matter then requires to be thoroughly mixed, either by hand or other agitators, and, when perfectly homogeneous, a sample is taken out and tested. As the artificial alizarin is always put into the stock tubs in a concentrated state, when its strength is known, water is added, to reduce it to the proper standard. As a precaution it is then re-examined, and if found of the proper strength, is drawn off into casks and sent to the consumer. There are always several stock tubs, the number greatly increasing where many shades of artificial alizarin are produced.

Instead of the "colour filters," for washing and draining the colouring matter above described, filter presses are now very frequently employed, as they act much quicker. In these the artificial alizarin can be concentrated, until it contains thirty or forty per cent. of dry colouring matter; but this is not necessary, as it is usually sent into the market with about ten or eleven per cent., these being convenient strengths for the dyer. The value of the colouring matter may be determined by evaporating a weighed quantity in a dish, and, when dry again, weighing. As it usually contains a little inorganic matter, the ash should be determined and weighed, but the more reliable method is to dye pieces of mordanted cloth, as in madder testing.

It will now be necessary to go back again a little, to the formation of the colouring matter from the soda salt.

I have mentioned the various changes through which the monosulpho and disulpho compounds of anthraquinone go when being converted into colouring matter. In the case of monosulpho-anthraquinone, it will be remembered that monoxyanthraquinone is first produced; and, in the case of the disulpho acids, anthraflavic and isoanthraflavic acids are produced before the colouring matters.

As I have already shown, these substances, when converted into colouring matter, by heating with caustic alkali, cause nascent hydrogen to form, which reacts upon other portions of them, reducing them to anthraquinone and hydroanthraquinone. The presence of this latter substance in the purple alkaline product from the pressure tubes is easily seen by exposing some of it to the air, when a film of anthraquinone will rapidly form.

As I mentioned before, this formation of anthraquinone and hydroanthraquinone represents loss of valuable products, which should have been converted into colouring matter, and it was, therefore, an important problem to solve as to whether it could be avoided. Success attended the experiments in this direction, and all that was found necessary was to introduce a quantity of potassic chlorate, containing enough oxygen to unite with the nascent hydrogen. The sodic monosulphoanthraquinonate, theoretically requires 13·2 per cent; the sodic disulphoanthraquinonates, 10 per cent. In practice, three or four per cent. more is usually employed, but any large excess must be avoided. This improvement was discovered by J. J. Koch.*

By employing chlorate of potash in this operation, the yield of colouring matter is very materially increased, as would be expected from the foregoing experiments. From experiments I have made, it is doubtful whether it acts upon the sodic sulphite at all. The conversion of monoxanthraquinone, isoanthraflavic acid, and anthraflavic acid, or their sodic derivation, into colouring matter, may by this modification be represented thus—

$$\underbrace{C_{14}H_7(ONa)O_2}_{\text{Sodio monoxyanthraquinonate.}} + Na\,OH + O = \underbrace{C_{14}H_6\left\{\begin{matrix}ONa\\ONa\end{matrix}\right\}O_2}_{\text{Sodic alizarate.}} + OH_2$$

$$\underbrace{C_{14}H_6\left\{\begin{matrix}ONa\\ONa\end{matrix}\right\}O_2}_{\text{Sodic isoanthraflavate or anthraflavate.}} + Na\,OH + O = \underbrace{C_{14}H_5\left\{\begin{matrix}ONa\\ONa\\ONa\end{matrix}\right\}O_2}_{\text{Sodic anthrapurpurate or flavopurpurate.}} + OH_2$$

It is also now found to be an advantage to use less water and more caustic soda. As this makes a very thick mixture, the pressure tubes previously described are not suitable for the operation, and instead of them very strong double rivetted boilers are used, about eleven or twelve feet long and four feet six wide. These are fitted with a stirrer, which is kept moving during the operation. A view of one of these boilers is seen on Fig. 7, *n*. These are fitted up practically in the same manner as the pressure tubes. They are, however, charged through the top man-hole, *o*. The mixture with which they are charged is about as follows, the amount, of course, being in proportion to the size of the boiler.

A quantity of the soda salt previously described, and representing 100 parts of dry salt, is mixed with about 400 parts of caustic soda, dissolved in as little water as possible, and 15 parts of potassic chlorate. The mixture is best made in the boiler, the stirrer

* *Moniteur Scientifique* April, 1879; p. 419.

being kept moving all the time, to render it homogenous.

If sodic monosulphanthraquinonate be used instead of the above soda salt, a little more potassic chlorate may be used, and somewhat less caustic soda, as a smaller amount of the latter substance is used up in the chemical reaction. The preparation of sodic monosulphanthraquinonate will be described further on.

The temperature used is about 170° to 180°, some manufacturers using somewhat lower and others higher temperatures. When the charge contains chiefly sodic disulphanthraquinonate, the operation is carried on for several days and nights, not unfrequently a week; but, if it contains sodic monosulphanthraquinonate, two to three days will be found sufficient.

I have often noticed, on heating a mixture of the mono and disulpho compounds with caustic alkali, that, by stopping the action early, only alizarin is produced, the decomposition of the disulpho acid, and consequent formation of anthrapurpurin, requiring considerably more time.

The products formed in these boilers are treated just in the same way as those from the pressure tubes previously described, *i.e.*, they are blown into iron tanks, diluted, acidified, and the precipitated coloured matter well washed.

I wish now to draw your attention to the first process we used for the preparation of artificial alizarin, viz., the process in which anthraquinone is employed. The anthracene we first used for this purpose was obtained from pitch. We then employed that from the tar distillers. In our earlier operations it was purified simply by treatment with naphtha and subsequent distillation, but afterwards by distillation with potash.

The purified anthracene was ground very thoroughly with water under-edge runners. It was then placed in a lead-lined tank, with twice its weight of powdered potassic bichromate dissolved in water. About three parts of sulphuric acid, previously diluted, were then added. After well stirring, a very energetic reaction set in, the mixture boiling up to near the top of the tank. When this had been moderated, steam was turned on, and the mixture well boiled for an hour or two. The yellow granular crude anthraquinone was then separated from the chrome alum solution, well washed, and after it had drained, though still wet, was purified by sublimation. At first we used two iron retorts, with openings at the top, and connected with a wide bent iron tube for this purpose, the one acting as a sublimer, the other as a receiver. Afterwards we employed retorts, with an outlet from the end connected with a large sheet-iron cylinder, having one end closed with canvas only.

The wet crude anthraquinone, when heated, gave off a considerable amount of steam, this helped to carry the vapour of the anthraquinone forward, which condensed as an impalpable powder. As the sublimation proceeded, and less steam was given off, small crystals of anthraquinone deposited. On opening the retorts after the operation, magnificent hard yellow crystals were often found suspended from the roofs of them.

The sublimed anthraquinone was then dried, and finally purified by crystallisation from high-boiling coal-tar naphtha. The crystallised product was collected on canvas bags, drained, washed with a little clean naphtha, pressed, and then dried.

The amount of pure anthraquinone we obtained from pitch anthracene was, speaking from memory, about twenty to twenty-five per cent. The yield from ordinary anthracene from the tar distillers, was, of course, much greater. The use of potash in the distillation of anthracene we did not adopt until after we had ceased using the anthracene from pitch, otherwise better results would have been obtained with this product.

Since these early operations were made, a great deal of attention has been, and is still being given to the preparation of anthraquinone. A number of experiments were made in my laboratory on the use of peroxide of manganese as the oxidising agent, but I never succeeded in obtaining such a satisfactory yield as when potassic bichromate was employed. Anthraquinone is now usually prepared in the following manner:—The crude anthracene is first washed with coal-tar naphtha. In employing this as the purifying agent, it is used cold, and well agitated with the anthracene, until every particle has been brought in contact with it. If the crude anthracene contains twenty or thirty per cent. of pure anthracene, it is treated with its own weight of naphtha.

The naphtha is then well drained off from the anthracene, which is afterwards pressed as dry as possible by means of a hydraulic press. If the quality is lower than twenty per cent., it is first treated with about one-fourth its weight of naphtha, and afterwards as if of a quality over twenty or thirty per cent. The adhering naphtha, which is generally about one-tenth the weight of the pressed anthracene, is then removed by steaming, and thus recovered, or it is allowed to evaporate away.

The naphtha which has been used is purified by distillation, and thus rendered fit for a fresh operation. An arrangement of apparatus, such as that described for treating anthracene with petroleum spirit, answers equally when naphtha is used, omitting the cooling tanks. Horizontal stirring machines are now preferred to the vertical ones, as, in the latter, the anthracene and solvent, after a short time, move round together with the stirrer, and therefore do not get well mixed. This, however, can be avoided, by fixing a few blades to the sides of the machine.

The anthracene, after treatment with naphtha, should contain about fifty per cent. of pure anthracene. It is not distilled in the same manner as for the preparation of dichloranthracene, but is heated in a retort, or, more generally, in a semi-circular iron pot. The lid of this is furnished with a safety-valve, and also a steam pipe. The receiver consists of a tank, the top of which is sometimes made of canvas; a perforated tube passes round this tank near the top, which is supplied with water, and produces a gentle spray, which facilitates the condensation of the anthracene. When working this arrangement, a known weight of anthracene is introduced into the iron pot, which may be called a subliming pot, and is heated until it is quite fluid. Steam is then blown in; this carries the anthracene vapour forward with it into the receiver, when both are condensed by the spray of cold water.

The condensed anthracene is found in a wet and

extremely finely divided state, very suitable for oxidation. Its weight is known from the amount of washed anthracene used in the operation. Other methods of condensing the anthracene and steam are used, but the above, I believe, is the most common. Obtaining the anthracene in this finely divided state is a great improvement upon the old process of grinding it.

The oxidation of this anthracene is performed much more slowly than it was at first, the solution of potassic bichromate and sulphuric acid being kept more diluted. In this way the amount of oxidising agent required is smaller, less being expended on the useless impurities.

In carrying out this operation in its present form, the potassic bichromate is first dissolved in water, and the wet anthracene well mixed with it. The requisite quantity of sulphuric acid, previously diluted with water, is then added by degrees, and the mixture kept gently boiling for ten or twelve hours. A Korting's air injector should be used with the steam, to keep up the agitation of the mixture. The oxidised anthracene, which has the appearance of a yellow powder, is then collected in woollen bags, thoroughly washed, pressed, and dried.

The amount of potassic bichromate used is regulated principally by the proportion of pure anthracene, contained in the product to be oxidised. Pure anthracene requires about 1·66 times its weight of potassic bichromate to convert it into anthraquinone. The amount used by different manufacturers varies, some employing a little under two parts, others more; but no fixed quantity can be given, as the amount required evidently must differ with the kind of impurities contained in different parcels of anthracene, some of these oxidising more freely than others. It is remarkable that so little answers the purpose, and shows that the anthracene takes up the oxygen more greedily than the impurities. Too much oxidising agent is injurious.

The anthraquinone is still very crude, and needs purification. The method that has been most generally adopted consists in treating it with concentrated sulphuric acid. This dissolves the anthraquinone, but does not act upon it. The impurities, however, become soluble in water, being converted in sulpho acids, &c., so that after treating the crude anthraquinone in this manner, and then mixing the product with water, nearly pure anthraquinone is alone precipitated. This method of subliming anthracene, oxidising it, and purify ing it with sulphuric acid, was first proposed, I believe, by H. Caro. The process is carried out as follows:—The crude anthraquinone is placed in large iron, semicircular, cast-iron pots, capable of holding a ton or more of the product. These are furnished with a steam jacket, and a strong stirrer, also of cast-iron, and worked by machinery, the blades being arranged so as to work the mixture constantly upwards. These pots are charged with crude anthraquinone and sulphuric acid, in the proportion of one of the former to three or four of the latter; the steam is turned on to the jacket, and the mixture heated with continuous stirring for about twenty-four hours. The product is then run into shallow leaden trays, and exposed to the air, or the trays are arranged in a proper chamber, the atmosphere of which is kept moist by steam. In this way the acid becomes very gradually diluted, causing the anthraquinone to crystallise out. In a proper chamber this occupies about two days. The crystalline product is boiled with water, and then washed by decantation, any anthraquinone found in the liquors being afterwards collected. The anthraquinone is then pressed and dried, and is usually so pure as to contain over 95 per cent. of anthraquinone.

Instead of placing it on trays, and allowing it to crystallise by the absorption of moisture by the sulphuric acid, some manufacturers pour it at once into water, boil the resulting mixture, and wash it in filter presses.

During the last year or two, a modification of our original process has been coming into use; I mean the process of sublimation. The modification principally consists in assisting the process by passing superheated steam through the subliming retort, and this is important.

Although anthraquinone is such a remarkably stable body, we often noticed that a good deal of loss occurred in our subliming operations, apparently from reduction, and especially if the charges were large, because they then required a high temperature continued for a long time, the residues being bad conductors of heat. This reduction is probably caused by the steam, and anthraquinone coming in contact with the iron of the retort. To avoid this loss, it is evident that the temperature should not be higher than absolutely necessary, and the charge should also be spread out in thin layers, so as to be quickly volatilised. The anthraquinone vapour and steam may be condensed in a similar manner to anthracene. The sublimed anthraquinone, which is pressed and dried, has to be still further purified. It will be remembered that we used coal-tar naphtha for the purpose, but the sulphuric acid process above described, I believe, is now always employed.

The large amount of chrome alum liquors produced in the manufacture of anthraquinone has always been a source of trouble to manufacturers, their dark green colour and acid character making them objectionable in the drains, and chrome alum being of itself of very limited consumption. Processes, however, have been now devised for working this up again into a chromate.

There is, however, another residue which, so far as I am aware, has not been turned to account, and that is the acid liquors from the purification of anthraquinone, consisting of sulphuric acid, sulpho acids, &c., and it is difficult to see to what use they can be turned, especially as such enormous quantities are produced, probably over 3,000 tons of sulphuric acid being used in this process yearly. If the original process of crystallising the sublimed anthraquinone from naphtha were adopted, this difficulty would not exist.

In converting the anthraquinone into the sulpho acids, we at first used Nordhausen sulphuric acid, and heated the mixture in glass retorts, such as are used in the concentration of sulphuric acid, but, owing to the fragility of these vessels, we were induced to try cast iron pots. These we found to answer very well, though not quite so well as glass.

On account of the expense and difficulty in getting Nordhausen sulphuric acid imported into this country—few vessels liking it as a cargo—we commenced working with ordinary sulphuric acid.

We usually employed four or five parts of this to every one part of anthraquinone, and heated the mixture up to 270°-280° C. The anthracene, as it sublimed from the operation, was put back into the acid. The sulpho acids produced in this way were treated with lime, &c., just as those obtained from dichloranthracene, and already described.

I find we employed this process principally in our works until the middle of June, 1870. We then began to work on a larger scale than we had hitherto done with dichloranthracene, and carried both processes on for a time; but, finding the latter the most economical, partially on account of the ease with which it yielded the sulpho acids with ordinary sulphuric acid, we employed it almost exclusively after a time, although frequently making colouring matter by the other method.

As already mentioned, in the early experiments made with anthraquinone, it was noticed that, by reducing the amount of sulphuric acid with which it was heated, and keeping the temperature as low as practicable, that the colouring matter produced with the resulting sulpho acids gave purples, on mordanted cloth, more closely resembling those produced with madder than when a large excess of sulphuric had been employed. The cause of this was not understood for some time, until it was eventually found out that a mono-sulpho acid was required to produce alizarin. I believe this was first discovered by Messrs. Meister, Lucius, and Brüning, as they were the earliest to send practically pure alizarin into the market.

The production of the monosulpho acid of anthraquinone as the chief product, by means of ordinary sulphuric acid, is difficult. I have generally thought it best, to work with an excess of anthraquinone, to use a high temperature and only small operations, so that they may be quickly finished. When using ordinary sulphuric acid, every facility should be given for the escape of aqueous vapour which forms so as to keep the acid as concentrated as possible. At temperatures over 260° C. sulphuric acid commences to oxidise anthraquinone, carbonic anhydride being slowly formed, so that high temperature should not be long continued.

The large quantity of ordinary sulphuric acid which had to be employed to convert anthraquinone into the sulpho acids, and the high temperature which had to be used, causing a certain amount of destruction to take place, evidently showed that it was desirable to employ fuming sulphuric acid in this process. In this country we found it costly, but as it was more readily procurable in Germany, the manufacturers there used it. They were afterwards supplied with a very strong fuming acid from Bohemia, containing about forty per cent. of sulphuric anhydride. This was prepared, I believe, by distilling the sulphuric anhydride from one portion of ordinary Nordhausen sulphuric acid into another. This very strong acid was found to be without action upon ordinary tinned iron, and it is now actually stored in vessels made of that material.

Within the last few years a very elegant process* has been devised by Dr. Messel and Mr. Squire, for the production of sulphuric anhydride and fuming sulphuric acid. Sulphuric acid, when strongly heated, dissociates into steam, sulphurous anhydride, and oxygen, thus:—

$$SO_4 H_2 = OH_2 + O + SO_2.$$

This decomposition is taken advantage of to give supply of sulphurous anhydride and oxygen in the proportions required, the water being condensed and thorougly removed by passing the gases through sulphuric acid.

The mixed gases are afterwards combined by passing them over heated platinised asbestos, and thus form sulphuric anhydride.

$$SO_2 + O = SO_3.$$

The sulphuric anhydride is then condensed, either alone or in ordinary sulphuric acid. It is remarkable that acid containing 60 to 70 per cent. of anhydride is liquid, even below 0° C.; acid containing 40 to 50 per cent. is solid, and acid containing 20 to 30 per cent., liquid. By this means fuming acid can be produced in any quantity, and of any strength; that usually employed in the manufacture of alizarin containing 40 or 50 per cent. of anhydride. We thus see that the demand for this acid in the production of artificial alizarin has created a new industry.

On treating anthraquinone with fuming sulphuric acid, iron pots, somewhat similar to those described for the conversion of dichloranthracene into sulpho acids, are used, but as but little acid vapours escape, very little provision need be made for condensing them. In fact, if the anthraquinone be pure, there is no reason why they should not be entirely closed, though, of course, it would be desirable to have a safety valve, or some similar sort of arrangement.

The sizes of the iron pots used for treating anthraquinone with fuming sulphuric acid vary, but usually hold from 30 to 40 gallons. They should be fitted with stirrers, especially when required for the preparation of the monosulphanthraquinonic acid, and heated by means of an oil bath. The fuming acid, after being sufficiently heated to render it fluid, is emptied into these pots by means of a syphon, or by piercing the tins, after having placed them over the pots by passing an iron bar right through the top and then through the bottom; the upper hole thus made serves as an inlet for the air, and allows the acid to flow freely through the hole in the bottom of the tin.

When the monosulphoanthraquinonic acid is required, a mixture of about one part of fuming acid, containing 40 to 50 per cent. of anhydride, is very thoroughly mixed with from one, to one and a quarter parts of anthraquinone. The mixture is then gradually heated up to about 170°, or even to 190°, and kept at this temperature for eight or ten hours, the stirrer being kept constantly in motion. The product thus formed consists chiefly of monosulphanthraquinonic acid, together with a little of the disulpho acid and unchanged anthraquinone. It is then removed from the pots whilst rather hot and diluted with water. The anthraquinone is then separated by passing this solution through a filter press, or other convenient arrangement.

* Patented 18th September, 1875, and now manufactured largely in this country by Chapman, Messel, and Co. Prof. C. Winkler, a short time afterwards also showed that fuming acid could be made in this manner.—Dingler, Polyt. Journ., ccxviii. 128-139.

The monosulpho acid is easily separated from the disulpho acid by converting it into its soda salt, which is difficultly soluble in water, this solvent dissolving only about five per cent. at the ordinary temperature. The filtrate is, therefore, nearly neutralised with caustic soda. This causes it to become a thick crystalline mass, which is then thoroughly pressed from the mother liquors; if required still purer, it can be re-crystallised, or purified by mixing it with about 15 or 20 per cent. of sulphuric acid, diluting with a little water, and again pressing and washing with water. This salt forms beautiful small brilliant white pearly scales.

When pure, sodic monosulphanthraquinonate gives, on heating with caustic soda and chlorate of potash, practically pure alizarin. This operation I have already remarked upon.

To make the disulpho acid from anthraquinone, an excess of fuming sulphuric acid is used, about twice as much, or rather more, than in the preparation of the monosulpho acid; the temperature is also raised (as combination of the products takes place) considerably higher; it may be allowed to rise, if a very red shade of colour is to be made, as high as 260°, but should not be taken much higher for any length of time.

The product thus obtained is perfectly soluble in water, and, when sufficiently cool, should be removed from the pots and diluted. It may then be treated with lime, as when dichloranthracene has been used, or, as some prefer, neutralised at once with caustic soda. It will then, of course, be mixed with a considerable quantity of sodic sulphate, and, so far as my experience goes, I have always found that the purer the soda salt the better it worked when treated with caustic soda to convert it into colouring matter.

Dichloranthracene, if treated with about twice its weight of fuming acid, containing 25 per cent. of anhydride, instead of with five times its weight of ordinary acid, works very well, and undoubtedly could be used at once by neutralising with caustic soda.

It is remarkable that the artificial alizarin produced from disulpho acids, prepared from anthraquinone, does not yield such pure shades of colour on mordants as that made with the disulpho acids, prepared from dichloranthracene. The latter colouring matter gives the calico printer more delicate pink and red shades, and is, therefore, also much liked by Turkey red dyers; and, notwithstanding it is sent into the market in a weaker form than the corresponding anthraquinone colouring matter, still it demands a higher price. Taking both circumstances together, the price it fetches is about twenty-five per cent. more than the colouring matter produced with anthraquinone.

The process with dichloranthracene has also the great advantage of always giving an artificial alizarin, producing uniform shades of colour, according as ordinary or fuming sulphuric acid is used, whereas with anthraquinone it is impossible to tell with certainty the exact tint the product you are making will give.

Curiously, continental manufacturers do not appear to have been as yet successful in manufacturing artificial alizarin from dichloranthracene in quantity, and what little they have produced in this way does not seem to have been equal in quality to that produced in this country.

The dichloranthracene and anthraquinone processes I have described are the only ones employed for the production of artificial alizarin. The method of converting anthracene into sulpho acids, and then oxidising them so as to form sulpho acids of anthraquinone, although apparently very simple, does not work satisfactorily, the yield of colouring matter being small. The only process I have found to approach those in use is that patented by Meister, Lucius, and Brüning, in which mononitroanthraquinone is used. By this process the only colouring matter dyeing mordants, produced, is alizarin, and from experiments I made I found the yield of colouring matter to be, on the whole, satisfactory. It is, however, obtained in a brown and impure condition.

When commencing to supply dyers and printers with artificial alizarin, we knew that we had to compete with madder. And although the new product possessed certain advantages, yet we felt it was useless to ask prices relatively much higher than those of that product, and from the first we endeavoured to act upon this principle.*

At first, nearly all the artificial alizarin we made was consumed by the Turkey red dyers of Glasgow and Manchester. The colour at this time contained large quantities of anthrapurpurin, and therefore produced a more scarlet shade than madder or garancine, and for some time it was used along with garancine, as, by this means, shades of colour were produced which were far more brilliant than when garancine alone was employed; but, at the same time, not too scarlet to be disliked by the Turkey red buyers. Of course, the use of garancine with artificial alizarin has now ceased, and much better results are obtained by employing a mixture of the red shade and blue shade.

Unfortunately, the market is now supplied, not only with the red, or anthrapurpurin shade, and blue, or pure alizarin, shade, but mixtures of these in various proportions, so that there are more than a dozen shades in the market, and thus much of the manufacturer's time is occupied with preparing these; moreover, he is forced to keep a considerable stock of colour on hand.

It would appear that on the Continent great difficulties were experienced in the use of artificial alizarin for Turkey red dyeing,† whereas in this country it was employed for this purpose from the very first, and no difficulties worth mentioning were experienced, the chief modification being, I believe, the use of soap only in the clearing process, instead of soap and an alkaline carbonate. Several modifications, however, have since been made in oiling and mordanting the goods, which have rendered the process more simple; and the colouring matter being a purer product than madder or garancine, the clearing operations can be performed with greater facility.

In dyeing ordinary printed goods the process can be conducted much more rapidly than when madder is used, as no loss of colouring matter is experienced by using a high temperature at once, as I showed you was the case with madder; however, I believe, when good pink and red shades

* The prices given in the *Moniteur Scientifique* (April 1879, p. 420), for the years 1870–1873, are very much higher than those ever obtained in this country.

† *Moniteur Scientifique*, April, 1879, p. 417.

are to be dyed, dyers do not usually allow their dye bath to rise much above 80-85° C.

The use of a product, called "oleine," prepared by treating castor and other oils with sulphuric acid, has been found of great service, as it increases the brilliancy of the shades, especially the red or scarlet ones.

A good deal of artificial alizarin is used for topical printing. To fit it for this purpose it is mixed with a few per cent. of its weight of acetate of lime, and by dyeing patterns with light shades, say, with pure alizarin, and then printing on dark shades with anthrapurpurin, very beautiful results can be obtained.

The use of artificial alizarin, in place of madder or garancine, has a very important influence in the pollution of our rivers, as when this is used the water from the dye baths is nearly pure, whereas when madder and garancine are employed it is full of ground woody matter, and I think I shall be making a very low estimate if I say that over 10,000 tons of this was annually passed into our rivers before the introduction of artificial alizarin. Surely this is a great advantage in itself.

Now that the production of artificial alizarin is equal to the demand, it is interesting to find that the supply of raw material, anthracene, has been quite adequate, so that all the fears that were entertained on this subject have proved groundless; and it is also well to remember that, up to the present time, the anthracene contained in pitch has not been extracted to any large extent, so that much more anthracene could yet be produced if required.

The tars from different gas works yield very different qualities and quantities of anthracene; this is to a great extent due to the kind of coal employed and the temperatures to which the retorts are heated in the gas works. To take two extreme cases. Newcastle coal yields a tar which is very suitable for the preparation of anthracene, whereas cannel coal gives a tar containing but little anthracene and a great deal of paraffin. Now, at some gas works, cannel coal is principally used, as in Scotland. At others, some is often mixed with Newcastle or other variety of coal, to increase the illuminating power of the gas; this is done frequently in cold weather. Thus tars of all sorts of qualities are formed, and, consequently, the kind and quantity of impurities in the anthracene prepared from them differ.

Further complications also arise in the tar works according to the way the distillation of the tar is conducted. If it is carried only so far as to leave a soft pitch in the still, it does not contain so many varieties of impurities as when the distillation is carried on until hard pitch is produced, or the pitch coked. Crude anthracene is, therefore, found to be not altogether of value according to the per-centage of anthracene it contains, but to a considerable extent upon the nature of the impurities associated with it. Thus, anthracene obtained from pitch is scarcely a saleable article to those who purify their anthracene by washing it with naphtha, and then by sublimation.

It would be very interesting to see if it would not be worth while distilling coal near the pit's mouth, for the purpose of manufacturing benzol, anthracene, and other useful products, selecting the most suitable qualities of coal, and employing temperatures, which experiment proved to be the most suitable. The gas and coke, of course, could be utilised as fuel. Should the supply of coal tar from any circumstance become insufficient, as, for example, by gas being superseded by the electric or any other source of light, this undoubtedly would have to be done, and it would be a great advantage to get products of a uniform quality.

It will, perhaps, be of interest here to record the prices paid for anthracene during the first year or two of the manufacture of artificial alizarin. In 1870-1871, we gave from 9d. to 1s. 6d. per cent. per cwt., and in 1872 from 1s. 6d. to 5s., and a small quantity at 5s. 6d. This shows how the price advanced with the demand*; since then there have been great variations, and much higher prices are said to have been given by some buyers.

The anthracene was at first valued by the bisulphide of carbon or petroleum and bisulphide of carbon tests, and also by the alcohol process, the present anthraquinone method not being then proposed. For our own information, we employed from nearly the first an anthraquinone test, which consisted in oxydising about 10 grammes of the anthracene, previously purified with petroleum and distillation with caustic potash, subliming off the anthraquinone in a retort, crystalising it from naphtha, and then weighing. This, although not very accurate, we found to be practically of much value to us.

As to the advantage of the use of naphtha or petroleum spirit for purifying anthracene, manufacturers differ in opinion. It is evident, however, that petroleum spirit has the great advantage of dissolving less anthracene, and, at the same time, the other impurities are sufficiently soluble in it to be removed if enough be employed, say two or three times as much as the crude anthracene to be purified; it is also easily removed from the purified anthracene by steam, on account of its volubility. Coal-tar naphtha, however, dissolves out a good deal of anthracene; so that the impurities dissolved by it, and left after it has been distilled off, contain often seven or eight per cent. of anthracene, which is difficult to recover. Neither naphtha nor petroleum remove much of the carbazol. The following is a table of solubilities of anthracene, &c., in benzene and petroleum:—

	Petroleum. B.P. 70°-100° C.	Benzene. B.P. 80°-100° C.
Anthracene	·115 per cent.	·976 per cent.
Phenanthrene....	3·206 ,, ...	21·94 ,,
Carbazol	·016 ,, ...	·51 ,,
Dichloranthracene	·137 ,, ...	·52 ,,
Anthraquinone ..	·013 ,, ...	·166 ,,

There is an impurity in anthracene which is sometimes very troublesome, and that is paraffin. This paraffin is of high fusing point, and of little solubility either in petroleum or in naphtha—very different in this respect from ordinary paraffin. It will dissolve in these solvents when they are hot, but on cooling is almost entirely deposited again. A small quantity of this left in the anthracene frequently greatly impedes the filtration in the succeeding operations, and being a stable compound, passes through most of the processes, it is, therefore, a very troublesome substance, and

* The prices of anthracene given in the *Moniteur Scientifique*, April 19, p. 420, are much too high.

interferes with the value of a crude anthracene containing it. Crude anthracene is very much purified by being hot-pressed, so much so, that if it is thoroughly done, it is scarcely needful to treat it with naphtha or petroleum. The anthracene which dissolves in the fused impurities, and is then pressed out, may be afterwards recovered.

I will now make a few remarks upon the process of distilling anthracene with caustic potash. This process has been very much spoken against, as destroying a considerable quantity of the anthracene. I may remark that anthracene is not acted upon by heating with caustic potash; and from all the experiments I have made on the subject, which are very numerous, I have not found that there is any more loss of anthracene by distilling it with caustic potash than by distilling it alone.

The effect of caustic potash on crude anthracene is very remarkable, sometimes as much as forty and fifty per cent. of impurities being removed by distilling it with this alkali. The action appears to be twofold; first, it chars all the difficultly volatile and unstable products and bodies of a phenolic character; and, secondly, it combines with the carbazol, forming with it a remarkable compound. Carbazol is present in considerable quantities; crude anthracene, after being washed with naphtha, containing from ten to twelve per cent. of carbazol; washed anthracene, which has been distilled with caustic potash, consist chiefly of anthracene and phenanthrene.

For the economical production of dichloranthracene, we found anthracene which had been purified by distillation with potash essential. This, when properly chlorinated, gives a beautifully crystalline mass, containing a certain amount of oily bodies, which can easily be removed by pressure. Whereas anthracence, which has not been treated with potash, yields a confusedly crystalline mass mixed with sticky impurities, which cannot be pressed out until rendered fluid by the addition of coal-tar naphtha, which results in a considerable loss of product.

One advantage of this process of treating anthracene is that it brings anthracenes of different origins to similar conditions—even pitch anthracene works perfectly well after being subjected to this process. It is also useful as indicating the origin of the anthracene. The further the distillation of the tar has been carried, it will be found the greater the loss of weight the crude anthracene obtained from it will suffer on distillation with potash, on account of the impurities it contains being more easily charred.

There is one curious fact in connection with the process. If anthracene which has been well washed with naphtha or petroleum be distilled with potash, it will be found that, on treatment with these solvents again, a considerable amount of impurity will freely dissolve out, apparently consisting chiefly of phenanthrene.

I know of no method of procuring anthracene in a pure state easily and in quantity but by purifying it by distillation with caustic potash. Anthracene thus treated, if washed with benzol, or other suitable solvents, and then dissolved in boiling benzole, will crystallise out on cooling in a most beautiful manner in nearly colourless plates with a blue fluorescence, one or two crystallisations rendering it perfectly pure. And this brings me to the subject of the use of pure anthracene in the manufacture of alizarin.

Generally speaking, as a manufacture advances, so the quality of the materials used are improved, and I quite think that the need of anthracene in a pure or purer condition than it is now employed in, will be found to be very desirable in the production of artificial alizarin. Just before I left off manufacturing this product, at the end of 1873, I was engaged upon experiments in this direction, for the purpose of improving the method of preparing dichloranthracene, so as to reduce the amount of chlorine oils formed, or to avoid their formation altogether. As chlorine forms, with pure anthracene, the theoretical amount of dichloranthracene, it is evident that if some convenient method were adopted to allow these bodies to freely react upon each other, pure dichloranthracene could be produced very cheaply, as there would be no loss and no purification needed. I quite think this might be accomplished.

The oxidation of pure anthracene for the preparation of anthraquinone does not succeed well by the process at present adopted, so that this would likewise have to be modified, but if it could be obtained pure, or nearly pure, at once, instead of having to be dissolved in oil of vitriol, or sublimed, and then treated with this acid, it would be a great advantage. To obtain anthracene in a pure, or nearly pure state on the large scale, I think that it would probably be found best to distil hot pressed anthracene with potash; then to grind it fine, wash it with petroleum or naphtha, and lastly crystallise it from naphtha.

I may here, perhaps, make a few remarks upon carbazol, as it is quite probable that it may yet be found to be a valuable product. To obtain it, anthracene, preferably hot-pressed or washed with naphtha, is distilled with caustic potash until no more anthracene passes over. The black residue, is then freed from potash by being well washed with water, and on being distilled, yields carbazol; as I mentioned before, crude anthracene gives as much as 10 or 12 per cent. of this substance. Another method consists in boiling the anthracene with fused caustic potash in a cylinder, until free from water, and then allowing the mixture to stand to cool. On opening the cylinder, the anthracene will be found as a layer on the top of the potash containing the carbazol, and can be scaled off. After this is removed, the remaining product is treated as just indicated.*

This remarkable compound of potash and carbazol, when heated to redness, gives off large quantities of hydrogen gas, the carbazol being decomposed. From experiments I have made, this compound appears to contain one atom of potassium to one of carbazol, its formula probably being $C_{12}\ H_8\ K\ N$. It is now under investigation.

Carbazol is a beautifully crystallised body, not unlike anthracene. When heated with mercuric chloride, or various other oxidising agents, it produces a blue colouring matter. This, however, has not been found to be of practical value. It is probably the substance which was described several

* The process of distilling crude anthracene with caustic potash was communicated to H. Caro, of the Badische Aniline and Soda Fabrik, and it was by this means that the carbazol investigated by Graebe and Glaser was obtained.

years ago as anthracene blue, the anthracene used probably containing carbazol.

In crude anthracene and oil, accompanying it, there is a peculiar organic base called *acridine*, having the formula $C_{12} H_9 N$. It was first observed by Caro, and investigated by Graebe and Caro. It crystallises in brownish yellow four-sided rectangular prisms, and is a most stable compound. The vapour causes sneezing and coughing, and it gives to the oils accompanying anthracene a very irritating action when rubbed on the skin. In hot weather, the workman employed in pressing or otherwise working with crude anthracene, sometimes suffer very considerably from the pain it temporarily produces.

Some improvement in the treatment of sulpho-acids of anthraquinone with caustic soda in the production of colouring matter is very desirable. The amount of alkali used is often six or eight times more than indicated by theory, and, as no suitable means have been obtained for recovering this before precipitating the colouring matter, it is all converted into sodic sulphate, for which a large amount of sulphuric acid has also to be employed. The sulphate of soda being in solution, does not pay for evaporation, otherwise it might be reconverted into caustic soda.

Some experiments have been made to precipitate the colouring matter from the alkaline solution with lime, but this, unfortunately, especially with red shades of colours, acts very imperfectly, and is therefore of no value. It is also very desirable that the condition under which the α and β disulpho-anthraquinonic acids are formed, as also of the disulpho acid giving the sulpho acid of alizarin should be studied, so that their separate formation may be effected at will.

Having now given an account of the manufacture of artificial alizarin, it will be interesting to inquire into the commercial results of this industry, and, firstly, what has been its influence upon the sale of madder and its derivatives. I mentioned at the commencement of this paper that the annual value of the imports into the United Kingdom, of madder and garancine, from 1859 to 1868, amounted to about £1,000,000 sterling, with prices averaging for madder 45s. and 50s. per cwt., and for garancine, 150s. In the subjoined table will be seen the remarkable changes that have taken place in the imports, and also the great reduction in price:—

AVERAGE ANNUAL IMPORTS OF MADDER AND GARANCINE INTO THE UNITED KINGDOM.

Year.	Madder.	Garancine.	French madder	Turkey roots.	Garancine.
	cwts.	cwts.			
1859 / 1868	305,840	45,560	45s.	50s.	150s.
1875	100,280	25,860	—	—	—
1876	59,137	15,396 or 6,436	—	—	—
1877	38,711	8,875	—	—	—
1878	32,990	2,790	18s.	17s.	65s.

Up to and during 1876 considerable quantities of artificial alizarin were imported from the Continent, and entered at the Customs as garancine or madder, which having been brought to the notice of the officials, the returns made subsequently are more reliable. The imports of garancine were returned by the Board of Trade in 1876 as 15,396 cwts. when first published, but in the following year, when the figures for 1876 were given for comparison with those of 1877 and 1878, the returns were stated as only 6,436 cwts. The erroneous entries were most probably made to evade the penalties for the infringement of patent rights.*

Dutch ground madder has been relatively much higher in price than the other qualities. This is owing to its extensive use in wool dyeing. For various reasons artificial alizarin has made but little progress in its application to wool dyeing, and Dutch madder being mostly used for this purpose, its prices have been maintained at from 28s. for ordinary "Ombro" to about 40s. to 45s. for crop madder. The wool dyers have, however, been working cautiously with artificial alizarin, and now some of them are using it somewhat largely, and considering its cheapness as compared with Dutch madder, no doubt they will soon find how to use it successfully and cease to employ madder.

The decline in the sale of madder is still rapidly going on. During the first two months of last year the imports were—

Madder	6,846 cwts.
Garancine	533 ,,

During the first two months of this year they were—

Madder	2,185 cwts.
Garancine	175 ,,

or about two-thirds less. And not only so, but the price is still declining. Turkey roots may now be bought at 11s. per cwt., whereas before artificial alizarin was introduced they were sold, on an average, at 50s. At the present prices of madder, its cultivation is unremunerative, and will, undoubtedly, be soon a thing of the past. Such has been the success of artificial alizarin in competing with madder and garancine in this country, and it is equally true of other countries. The quantity of madder grown in all the madder-growing countries of the world prior to 1868 is estimated at about 70,000 tons per annum. The amount of artificial alizarin now produced is equal in dyeing power to considerably more than this; in fact, the lowest estimate I have been able to get for 1878, and which was confirmed from other sources, is 9,500 tons, which is equivalent to 950,000 tons of madder. This remarkable result has been arrived at in ten years only.

To produce this quantity of artificial alizarin, there are about nine manufacturers on the Continent, and one in this country, Messrs. Burt, Bolton, and Haywood, who have two large works for its production, viz., the original works at Greenford-green, and new ones at Silvertown.

Graebe and Liebermann, in their paper in the *Moniteur Scientifique*,† give some statistics of the production of artificial alizarin which, however,

* A method so often resorted to as to render English chemical patents nearly useless as a protection against infringements by foreign manufacturers, the results of this being alike detrimental to the inventor and injurious to the national interests.

† April, 1879, p. 416.

requires correcting. They also leave out the years 1869 and 1870. In 1869 we had advanced in the manufacture so far as to send colour into the market, the first invoice being dated October 4th, and that year we produced about one ton. In 1870, we produced 40 tons; in 1871, 220 tons; in 1872, 300 tons; and in 1873, 435 tons. Up to the end of 1870 we were practically the only makers of this product. One of the largest chemical and coal tar colour manufacturing firms of Germany, with whom we were in correspondence, stating that in November, 1870, they had only lately commenced producing 50 lbs. of alizarin, 10 per cent. quality, per day, and that no one else in that country was supplying artificial alizarin, and in 1871, we were practically the only producers of quantity at any rate during the first part of the year, for in March, 1871, the firm already referred to, and who had great opportunities of knowing what was being done in their country, wrote that they had not received knowledge of any establishment but their own manufacturing artificial alizarin.

In November, 1871, however, Messrs. Gessert Frères announced to the Industrial Society of Mulhouse that they had produced 30,792 killogrammes of alizarin in paste. This is equal to about 30 tons, an amount which was evidently considered by them a very large quantity.*

Graebe and Liebermann's statistics are as follows compared with our production:—

	Graebe and Liebermann. Tons.	Perkin and Sons Productions. Tons.
1869	....	1
1870	....	40
1871	125-150	220
1872	400-500	300
1873	900-1,000	435

Without wishing to detract from Graebe and Liebermann's original discovery, we may say, that the birthplace of the manufacture of artificial alizarin was in England. It was in this country that the difficulties and doubts about the manufacture and supply of the raw material, anthracene, were solved, and the production of artificial alizarin by new processes successfully accomplished. After these results were obtained in this country, Continental chemists were encouraged to manufacture on a comparatively large scale, but up to the end of 1873 the English manufacturers had practically no competition in the home market.

Having considered the amount of artificial alizarin now manufactured, it will be of interest to see what its money value is.

Taking the lowest estimate, viz., 9,500 tons, and calculating its selling prices at £150 per ton, the annual value amounts to no less than £1,425,000, or nearly a million and a half.

As a dye, it is now at most not more than one-third of the average price of madder in 1859-1868. Consequently, in the United Kingdom, when the annual value of madder imported was £1,000,0000, the annual saving is very great.

While collecting the statistics about alizarin, I thought it would be of interest to get, if possible, the statistics of the entire coal tar colour industry, and to the kindness of H. Caro, of the Badische aniline and soda Fabrik, I am indebted for most of the following particulars:—

ESTIMATED VALUE OF THE PRODUCTION OF COAL TAR COLOURS IN 1878.

Germany	£2,000,000,	of which four-fifths are exported.
England	450,000	
France	350,000	
Switzerland	350,000	
Total	£3,150,000	

In referring to the works which have been set up for the purpose of making coal tar colours, I thought it would be of interest to show a copy of a rough sketch of the first works erected for this purpose as they appeared in 1868, two years after the patent for the mauve was taken out.

These works were not one year old when sketched, and the practicability of making the mauve commercially had only been proved a short time. In 1873 they had increased to such an extent as to cover about six acres, They are represented at this date by a copy of a photograph.*

There are now in this country six coal tar colour works; in Germany, no less than 17; in France, about five; and in Switzerland, four. There are also three works in Germany and three in France which manufacture aniline in enormous quantities for the production of coal tar colours.

Such is the wonderful growth of this industry, which dates only from 1856. It is the fruit of scientific researches in organic chemistry, conducted, mostly, from a scientific point of view; and, while this industry has made such great progress, it has, in its turn, acted as a handmaid to chemical science, by placing at the disposal of chemists products which otherwise could not have been obtained, and thus an amount of research has been conducted through it so extensive that it is difficult to realise, and this may, before long, produce practical fruit to an extent we have no conception of. One very important colouring matter related to coal-tar, and one of the original sources of aniline—a product of as great importance as alizarin—has yet to be produced on the large scale. I refer to indigo. Baeyer has shown that it can be produced artificially, but at present no practical means of accomplishing it have been discovered. No doubt, however, it will not be many years before this is achieved, and the cultivation of the indigo plant share the fate of madder.

The Chairman proposed a hearty vote of thanks to Mr. Perkin, not only for the present lecture, but for the equally interesting one delivered a fortnight previously. Mr. Perkin had dwelt with very justifiable pride on the fact that England had been the birthplace of this particular branch of industry connected with the coal-tar colours, of which he had given the history in a so lucid a manner. He had not, however, recalled to their minds that which was also true, that England was also the birthplace of the entire coal tar industry, the development of which he had so graphically and clearly narrated. He had also, with the modesty which they

* *Moniteur Scientifique*, April, 1879, 416.

* A copy of a photograph of the works as they appeared in 1873, and a facsimile of the sketch referred to in the text, showing the works in 1858, is given in a lithograph issued as a supplement to this number of the *Journal*.

all knew him to possess, forgotten to mention that he himself was the inventor and founder of this industry, which must compete in importance and interest with any other industry, either in England or any part of the civilised world. He regretted that Mr. Perkin had been compelled to give only an abstract of his full paper, and to bring before them merely an outline of the very important subject. It was, therefore, out of his power to invite further remarks, which might illustrate the points which Mr. Perkin had been unable to take up with regard to the alizarin industry. Much which want of time had compelled Mr. Perkin to omit would appear in the full text of the paper when it was published in the *Journal*. He could only, therefore, ask the meeting to return a cordial vote of thanks to Mr. Perkin for his able lectures, for the pains he had taken to illustrate them, and for the interesting experiments he had shown.

The motion having been carried unanimously,

Mr. Perkin briefly responded, and the meeting adjourned.

MISCELLANEOUS.

BRITISH ASSOCIATION.

The following arrangements have been made for the forty-ninth meeting of the British Association, to be held at Sheffield:—

The first meeting of the General Committee will be held on Wednesday, August 20th, at 1 p.m., for the election of the president and sectional officers, and the dispatch of business usually brought before that body. The General Committee will meet again on Monday, August 25th, at 3 p.m., for the purpose of appointing officers for 1880, and of deciding the place of meeting in 1881. The concluding meeting of this committee will be held on Wednesday, August 28th, at 1 p.m., when the report of the Committee of Recommendations will be received.

The first general meeting will be held on Wednesday, August 20th, at 8 p.m., when William Spottiswoode, M.A., D.C.L., L.L.D., Pres. R.S., will resign the chair, and Professor G. J. Allman, M.D., LL.D., F.R.S., president elect, will assume the presidency, and deliver an address. On Thursday evening, August 21st, at 8 p.m., a *soirée*; on Friday evening, August 22nd, at 8.30 p.m., a discourse by William Crookes, F.R.S., on "Radiant Matter;" on Monday evening, August 25th, at 8.30 p.m., a discourse by the Rev. W. H. Dallinger, on "The Life Histories of the Minutest Organic Forms, and their bearing on the Doctrine of the Origin of Species;" on Tuesday evening, August 26th, at 8 p.m., a *soirée*; on Wednesday, August 27th, the concluding general meeting will be held at 2.30 p.m. On Saturday evening, August 23rd, Mr. W. E. Ayrton will deliver a lecture to the operative classes, on "Electricity as a Motive Power." Excursions to places of interest in the neighbourhood of Sheffield will be made on Thursday, August 28th.

The following is a list of officers for the various Sections:—A. Mathematical and Physical Science.—*President*, G. Johnstone Stoney, M.A., F.R.S.; *Secretaries*, J. W. L. Glaisher, M.A., F.R.S., Oliver J. Lodge, D.Sc., and D. McAlister, B.A. B. Chemical Science.—*President*, Prof. J. Dewar, M.A., F.R.S.; *Secretaries*, H. S. Bell, F.C.S., W. Chandler Roberts, F.R.S., and J. M. Thomson, F.C.S. C. Geology.—*President*, Prof. P. M. Duncan, F.R.S.; *Secretaries*, G. B. Walker, F.G.S., and W. Topley, F.G.S. D. Biology.—*President*, Prof. St. George Mivart, F.R.S.; *Secretaries*, A. Jackson, F.R.C.S., Prof. McNab, M.D., and J. Brooking Rowe, F.L.S., Prof. Rudler, F.G.S., and Prof. Schäfer, F.R.S. E. Geography.—*President*, Clements R. Markham, C.B., F.R.S.; *Secretaries*, H. W. Bates, F.L.S., and E. C. Rye, F.Z.S. F. Economic Science.—*President*, G. Shaw-Lefevre, M.P.; *Secretaries*, Prof. Adamson, R. E. Leader, B.A., and C. Molloy. G. Mechanical Science.—*President*, J. Robinson, Pres. Inst. Mech. Eng.; *Secretaries*, A. T. Atchison, M.A., E. Bainbridge, and H. Trueman Wood, B.A.

The different Sections will assemble in the rooms appointed for them, for the reading and discussion of reports and other communications, on Thursday, August 21, Friday, August 22, Saturday, August 23, Monday, August 25, and Tuesday, August 26, at 11 a.m. The reception-room will be opened on Monday, August 18, at 1 p.m., and the following days at 8 a.m.

PROFESSOR HUGHES'S AUDIOMETER.

Dr. Richardson, F.R.S., read two papers at the Royal Society, on Thursday, 15th inst., which have attracted much attention. One contained the description of a method by which the telephone is used to make the movements of the pulse audible, with a very remarkable result. The other paper was entitled, "Some Researches with Professor Hughes's New Instrument for the Measurement of Hearing: The Audiometer."

The instrument consists of two Leclanche's cells for the battery, a new and simple microphone connected with the cells, and with two fixed coils (primary), and a secondary or induction coil, the terminals of which are attached to a telephone. The induction coil moves on a bar between the two fixed coils, and the bar is graduated into 200 parts, by which the readings of sound are taken. The graduated scale is divided into 20 centims., and each of these parts is subdivided into 10, so that the hearing may be tested up to 200°; from 200° maximum to 0° zero.

In using the instrument, one Leclanche's cell has been found sufficient, as a general rule, but two have been used in instances where the hearing of the person under test has been very defective. The Leclanche cell was selected by Professor Hughes as affording a reliable current for the purposes he had in view, and for standard comparisons. In using the instrument, the induction coil is moved along the scale from or towards the larger primary, as may be required, and the degree of sound is read from the figures on the scale, the sound being made by the movement of the microphone key between the battery and the primary coil.

The person whose hearing is being tested should sit in an easy position, and should not see the act of the observer in moving the microphone key. For good observation, the room in which the observation is made should be large, and all external causes of sound, such as the ticking of clocks, the vibrations of windows and doors, the moving of feet and the singing from gas jets, should be silenced. The sitter should close the ear that is not applied to the telephone while he is listening for minute sounds, and should give his full and calm attention to the proceeding. Any excitement is like to lead to error when refined measurements are required.

Capacity of the Instrument for Observation.—The instrument may be considered the most satisfactory means for testing the hearing power of all persons who can define a sound. The range of sound is sufficient at the maximum—200°—for everyone who is not absolutely deaf; 0°, or zero, is a point of positive silence from the instrument, or rather from the sound which it produces through the telephone.

Phenomena from Observations made on different Persons.—*Abrupt Loss of Sound.*—One of the first facts learned with the audiometer is the suddenness with which the

sound is lost on those who are listening. The sound is abruptly lost within a range of 2°, that is, within one-hundredth part of the entire scale. This is the case with those who are very deaf as well as with those who hear readily, a fact originally noticed by Mr. Hughes, and which the author has corroborated by fifty special observations on different persons presenting powers of hearing which varied from 200° to 140°, as the extreme limit or capacity, to complete hearing through the whole scale down to zero. In these persons, when the observation was taken, under the strictest possible conditions for surrounding silence, the point between distinctness of sound and complete loss of it was not more than one-hundreth part of the scale.

Continuous Hearing in Line.—In testing the capacity of hearing, it is noticeable that the power to detect the diminishing sound is maintained best by continuing the reduction in trace or line while the attention is fixed. A sudden break may cause the sound to be lost to the listener long before his real incapacity to hear is reached. If, for instance, the sound be very faintly heard at 15°, and the induction coil be suddenly moved to 5°, the sound at 5° may be quite inaudible; but if the coil be slowly moved, degree by degree, from 15° to 5°, the sound at 5° may be distinctly heard. Mr. Maitland Tate, C.E., who noticed this point very markedly in his own case, when the author was submitting him to test, compared this to what is observed by the sense of sight in making surveys. The eye will follow a line to an extreme point with comparative readiness, but if it break away from it the object seems to have disappeared.

Influence of Respiration on Hearing.—The effect of filling the chest and holding the breath makes a difference in listeners. The capacity for hearing is for a few seconds increased by holding the breath. Mr. Tate, who could hear with his right ear only down to 8° under ordinary breathing, could hear down to 5° when he held his breath. Another gentleman, who could hear only down to 100° under ordinary breathing, could hear to 80° when the breath was held with the chest full. Holding the breath with the chest not full fails to produce the same result.

Influence of habitual Movements of the Body.—As a rule, the hearing of persons who are right-handed is most refined in the right ear, and as most persons are right-handed, it is found that the right ear is the best ear. This rule is, however, attended with many exceptions, since, for various reasons, persons who use the right hand exclusively, practice for some particular purpose the use of the left ear, upon which that ear becomes more acute. Thus five physicians, who had accustomed themselves to use the stethoscope with the left ear, could hear to zero on that side, but had lost from 4° to 5° on the right side. Four other persons who were similarly circumstanced, were able at once to account for the fact by the habit they had acquired of listening to a public discourse or sermon from the left side. The interest attaching to this observation is, that the practice of using one ear for special refinement of the sense seems for the time slightly to impair the other ear, although there is no physical evidence of such impairment.

Influence of some Automatic Adjustment and of Memory in Hearing.—Connected with the last-named fact is another, namely, that by this instrument the deaf are found to fail in capacity of hearing, not only by reason of physical defect, but also by failure of memory of sounds. Thus, in a youth who had suffered serious defect of hearing for seven years, owing to partial destruction of the tympanum, and who in the right ear could only detect sound at 107°, there was an inability to catch all the sound lying between 130° and 107°, until he could remember what he had to listen for. By practising him then to detect the lowest sound that he was physically capable of receiving, the author got him to detect this one sound more readily than those which came higher up, between 107° and 130°. By further practice, all the intervening sounds became audible with equal facility. These facts, which have been confirmed by another observation on a different person, seem to the author to indicate that deafness from imperfection of the tympanum, or other parts of the organ of hearing, may be measured, beyond the mere physical failure, from some lost power of automatic adjustment in the auditory apparatus, and from failure of receptive power in the cerebrum itself, so that the memory, rendered imperfect, is slow to assist the listener, until by exercise of function its readiness is restored.

Influence of Atmospheric Pressure.—By use of the audiometer, the influence of atmospheric pressure on hearing is detectable. In the author's own case, when the barometer is 30°, he can hear on both sides close down to zero; but below 30° he fails by 2° on the left side to reach zero. In another person the failure under the same pressures extends to a loss of 4°.

Observations on Lower Animals.—The author tried to determine in some of the lower animals whether there is the same sense of hearing as in man. In most animals it is difficult to obtain sufficient quietude to enable the observer to gather from expression or movement of the animal, the information sought for. In two dogs, one a terrier, the other a field spaniel, the author succeeded in making some good observations, and in them the range of hearing power seemed to be distinctly lower than in the human subject who has perfect hearing. In both these animals, which were healthy, and in the prime of life, the first indication of the detection of sound commenced at 10° on the scale. The detection was evidenced by the sudden expression of listening, by a slight change of position, and a slight dilatation of the pupils. This detection was clearly made on the instant, as if the fact of hearing were abrupt, as it is in the higher animal.

Dr. Richardson concluded his paper with a statement of his views, as to the uses to which this instrument may be put, among which are the following:—

The audiometer will, he thinks, be an esssential in all physical inquiries of men who are undergoing examination as to their fitness for special services requiring perfect hearing, such as soldiers, sentries, railway officials, and the like.

The instrument will be of great use to the physician, in determining the value of hearing in those who are deaf, and in determining the relative values of the two organs of hearing. In one instance, already, he has been able by its means to detect in a person, who was supposed to be equally deaf on both sides, that on one side the hearing is perfect close up to zero, while on the other side nine-tenths of the hearing is lost.

The instrument may be used to differentiate between deafness through the external ear and deafness from enclosure of the Eustachian tube—throat deafness. In his own case the author fails to detect sound by the mouth at 170°, and this is a fair average in those who are healthy. It represents the comparative value of communication by sound through the Eustachian canal and the external ear.

The instrument promises to be of great service in determining the value of artificial tympanums, in instances of deafness due to imperfection or destruction of the natural tympanum. The cotton artificial tympanums, introduced originally by the late Dr. Yearsley, and the membranous tympanums introduced by the late Mr. Toynbee, F.R.S., have proved of much service; and by means of the audiometer Dr. Richardson has been able very accurately to test their respective merits, and to compare both with tympanums made of other material.

The Watford and West Herts Association for the **Improvement of Elementary Needlework will hold their Second Exhibition in the Agricultural-hall, Watford, on Saturday, June 21st. The prizes are to be distributed by Lady Dacre.**

NATIONAL CULTIVATION OF MUSIC.

The Bishop of Manchester, on Sunday, 18th May. preached to a crowded congregation in the Parish Church, Bury, in aid of the Lancashire Association for the Cultivation of Music among All. He said that, at present, he was afraid we were not doing very much, notwithstanding our system of popular education, in the direction of the cultivation—or artistic cultivation—of the musical faculties, and what little we were doing was not being done very satisfactorily. The Government paid about £120,000 a year for teaching music in schools. There were about 2,400,000 children in average daily attendance, so that the Government grant amounted to about 1s. per child per annum for the teaching of music. Looking at the last report of the Committee of Council on Education, he found that there were 19,921 departments of schools in which music was taught only by ear, and that, he supposed, was hardly any teaching at all, or, at least, a kind of teaching for which no competent musician would give much. In 697 departments the children were taught by what was called Hullah's system; in 2,297 departments, of which 1,000 were in School Board schools, they were taught by what was called the tonic sol-fa system, which he was told was very good up to a certain point, and in 534 departments upon the old system of notation. There were, he found, 3,502 departments in which music was taught upon a scientific or quasi-scientific method, and 19,921 departments in which at the present moment singing was only taught by ear. The Association, in behalf of which he was preaching, was established last year, and had been taken up by persons of influence throughout the county. It had begun its work, but it had no great amount of funds at its disposal. It had already, however, founded 12 scholarships for teachers in schools in Manchester, and there was no doubt that, with more means, its work would be very much extended. The idea in the minds of its promoters was that, in all the great centres of Lancashire, classes might be formed and musical instruction given, so that the result might be a general diffusion of musical knowledge. The Bishop expressed his approval of the scheme of the Association, and appealed for aid in its behalf. He also approved of singing in churches on week days, accompanied by instruments.

ANCIENT ENGINEERING.

A paper was read by Mr. George Burnham, jun., at a late meeting of the Philadelphia Engineers' Club, on the subject of "Some Features of Ancient Engineering." Modern research, he said, has developed the fact that nearly all the materials (in a very wide sense of the word) of modern civilisation originated in antiquity; the peculiar province of our time being to ring the changes of variety upon these elements and give them an immense diffusion. The textile fabrics of wool, cotton, flax, and silk, were known to the Egyptians of three or four thousand years ago; but the cotton-gin, the power-loom, and the steam-engine have greatly increased their variety, and put them into the hands of everyone. The same thing is true of the engineering art, for, if we except iron framing, the ancients originated nearly all the typical forms we now employ. They were acquainted with the constructive uses of wood; carried stone construction to a point that we have never since reached, and probably never shall; their brick work dates from the very earliest times, and they constructed canals and aqueducts for irrigation, water supply, and inland navigation, as as well elaborate drainage systems, long before their civilisation culminated.

The Chaldean structures, dating from 2200 to 1500 B.C., were built of small sun-dried bricks laid in bitumen, and faced with kiln-dried bricks stamped with the name of the king. These temples were built on elevated platforms of beaten clay, in some instances cased with massive walls of stone, the object being to raise them above the level of the plain for architectural effect and to avoid inundation. A brick burial vault at Mugheir exhibits a rudimentary arch. The vault is seven feet long, five feet high, and three feet seven inches wide. The sides slope gently outwards until the springing line is reached, when the successive courses are pushed towards each other until they meet at the top. Similar arches are found in early Greek work at Phigalia, Messene, and other places. The old notion that the round arch was of Roman and the pointed arch of Gothic origin has been dissipated by the spade of archæologist. Both of these varieties are found in Assyrian work. They are usually of brick, and occur in underground construction as drains and vaults. The brick arch existed in Egypt as early as 1540 B.C., and a stone arch has been found dating from 600 B.C.

The masonry of the past is, of course, identical with ours, since we have simply adopted the methods of the ancients. We find in Egypt and Western Asia smooth and rock-faced ashlar, rubble, and irregular range work essentially like that of to-day. The Assyrian and Egyptian bas-reliefs indicate their method of moving heavy masses. Sledges were used, drawn by large bodies of men. Rollers were placed under the sledge, and the piece was carefully "guyed" by parties of men with appropriate ropes and props. The Roman military roads crossed mountains and valleys without regard to the nature of the ground; tunnels, open cuts, embankments, and bridges frequently occurring. Place cross ties and steel rails upon a Roman road, and suppose the grade not too steep, and the points of approach and divergence of modern and ancient engineering are at once apparent. Substantially, the substructure was the same as that of the modern railroad; but, in place of the pedestrian or the ox-team, we have the locomotive, with its "Fast Express," or heavily-laden freight train.—*The Architect.*

A NEW FODDER-YIELDING TREE FOR INDIA.

At page 72 of the *Journal of the Society of Arts* for December 20th, 1878, in the notice of the report of the Calcutta Botanic Garden, a reference is made to the introduction into the garden of a South American tree, known as *Calliandra saman*. Besides its introduction into the Calcutta Garden, the prospect of its general cultivation in India as a fodder-yielding tree has been brought before the Agricultural and Horticultural Society of India, and seeds obtained, some of which have been transferred to the Society's garden, and the remainder distributed among the members. A report on the tree has also been obtained from the superintendent of the Botanic Gardens, Jamaica, from which the following particulars are gathered:—The tree seems to be popularly known in Jamaica as the "guango," and is one of the most magnificent features in the existing Jamaica Flora. It is supposed to have been originally brought from the American mainland as seed by Spanish cattle, and has now become thoroughly naturalised in all the dry regions. It is described as a lofty tree, in general habit much resembling the English oak. The trunk is thick, generally short and branched a few feet from the ground. The primary branch divisions are often tree-like in size, measuring nine to twelve feet in circumference at the base. The lower branches spread horizontally, and the upper are erect, spreading, giving the tree a flattish dome-shaped appearance. Trees are not unfrequently seventy feet high, the diameter of whose branch expansion horizontally is over 30 feet.

The shade which this tree affords, is of a light lifesome character, with gleams of sunlight stealing through and flitting about as the branches wave with the breeze. This characteristic, coupled with the fact, which is of equal importance to healthy vegetation, that the leaves and leaflets rigidly close together at night, thus admitting the free descent of the dew to the ground, together with its squat-like brooding habit, form its first great value as a pasture tree. It is without doubt the finest pasture tree on the island. Grass grows freely within the overshadowing of its ample arms, close up to its trunk. On this account alone it should be planted in pastures wherever it will thrive as a grateful shade for cattle. Beyond this is the important consideration of its being a fodder-yielding plant itself, and this in an important degree, both for quantity and quality of the yield. The fruit, when ripe, is a bright dark brown pod, six to ten inches long, barely an inch wide, and a quarter of an inch thick, the substance of the pod consisting of a sugary amber-coloured pulp. These pods are borne in great profusion, and hang, before arriving at maturity, dangling in clusters from every branchlet. As they ripen, they drop to the ground, and are picked up and eaten with much relish by all stock, even sheep and goats. Cattle may be seen lingering about the trees, waiting for the passing breeze to shake the fruit down. Its excellent quality as a fodder is evident by its fattening effect. Stock having access to it improve markedly during the time it is in season. From the sugary nature of the pod, it will keep good a long time, packed after maturity. It is, therefore, often gathered, packed in barrels, and kept for use till the dry early spring season has parched up the grass, and made herbage scarce. The tree thrives best in dry, hot plains, having a small or moderate annual rainfall. It is true, very large trees are occasionally found in wet districts, but they lack the conspicuously healthful and luxuriant branch development of trees on the plain. They are also much less fruitful, and the fruit is less plump and mucilaginous in substance. Hot plains, having an annual rainfall of from 30 to 60 inches, appear best adapted for its successful growth. Like many other plants, too, there is no doubt that a maritime influence is particularly favourable to its development.

The tree is a very rapid grower, and, if it were extensively cultivated, the pods would, no doubt, become largely used for feeding cattle. As a shade tree, along roadsides or open places of resort, it has special recommendations, and no doubt will be largely planted as it becomes more known.

CORRESPONDENCE.

ON THE MAXIMUM OF PHOTOGENIC ACTION.

The deep interest taken by the public generally, at the present moment, in all that relates to the cost of production, the purity of composition, and the efficiency of the gas employed for lighting purposes, may probably render acceptable to your readers the accompanying analysis and investigation of the phenomena of gas flames. The result obtained thereby (which in principle is exact and real, though in practice, as in all such cases, it can be only approximate), will serve to show the great importance of the form and construction of the burners employed to regulate the supply of air for combustion, adjustments which have hitherto been too much left to guess-work, or even to fancy. It is not impossible, moreover, that it may lead to modifications in the composition of the gas itself, and to methods of utilizing it, which would give us more intense as well as cheaper light. If we burn carburetted hydrogen gas with a great excess of gas, or with a great deficiency of air, we obtain a dull, red, smoky flame; if we supply air up to the exact point of complete combustion, we obtain a pale rose-coloured flame, emitting a feeble and almost imperceptible light, and enclosing a small interior flame of a fine azure colour, little less feeble. The phenomena of flame light being thus palpably due to the intense ignition of fine particles of carbon released from their union with the hydrogen, and the light being the more intense (up to a certain point) as the temperature increases, it becomes interesting to learn at what point the most intense light possible is attainable. The heat is due to the combustion of all the hydrogen, and of part of the carbon, which latter increases as the light becomes less intense. It thus becomes evident that conflicting claims, as it were, are set up, on the one side, for carbon employed to heat, and, on the other, for unconsumed carbon, the office of which is to receive heat and to give out light, while the total stock of carbon, the subject of this competition, is a fixed quantity. If a double weight of carbon be thus ignited, it must give out a double quantity of light; if, again, the same weight be raised to double the temperature, it must emit proportionally more intense light. We, therefore, cannot be far wrong if, representing the free unconsumed carbon by C, we assume the intensity of the light to be jointly as this residual carbon and as the temperature; or A being a constant, T the temperature in Centigrade degrees, and I the intensity, we take $I = A\ C\ T$. At any moment let W be the total weight of the body of gas in a state of flame. We may suppose the apparently continuous flame to consist of a series of rapidly succeeding explosions, which is probably the fact, as we know it to be so in the case of pure hydrogen. Let $m\,W$, then, represent the hydrogen, and $n\,W$ the carbon, where $m + n = 1$. Put $x =$ the carbon consumed in heating the residual carbon or $n\,W - x$, $m\,W$ being the hydrogen simultaneously burned, and producing vapour of water and nitrogen, while the carbon produces carbonic acid and nitrogen. Let u_1 be the units of heat due to 1lb. of hydrogen; u_2 the heat units of 1lb. of carbon; c_1 the specific heat of carbonic acid; c_2 that of nitrogen, and h that of the vapour of water. Then, as $I = A\ C\ T$ and $C = n\ W - x$, we have to express in the above symbols the value of T. Now, by the known relations under the above conditions, we have—

$$\text{Temperature of combustion} = \frac{\text{Total heat units}}{\text{Sum of heat units due to } 1^\circ \text{ C. in the products of combustion.}}$$

That is

$$T^\circ = \frac{m\,W\,u_1 + u_2\,x}{c_1\,(1 + \tfrac{16}{6})\,x + c_2\,\tfrac{16}{6} \cdot \tfrac{77}{23} \cdot x + 9\,m\,W\,h + 8\,c_2\,m\,W \cdot \tfrac{77}{23}}$$

[Strictly speaking, the denominator should include a term $c_3\,(n\ W - x)$, where c_3 is the specific heat of carbon, but this could be easily introduced if extreme accuracy of numerical calculation be required in any given case. This carbon is one product of the combustion.]

Put this denominator $= a\,x + b$; thus, we have

$$I = \frac{A\,(n\ W - x)\,.\,(m\ W\ u_1 + u_2\ x)}{a\,x + b}$$

This is to be *a maximum*, and, to determine it, we must find the differential coefficient $\frac{d\,I}{d\,x}$ of I with respect to x, put it $= o$, and from the resulting equation obtain the value of x. This value corresponds to the *maximum* intensity of the light required. That is to say—

$$\frac{(a\,x + b)\;d\,x\,[(n\,W - x)\;(m\,W\,u_1 + u_2\,x)] - a\;(n\,W - x)\;(m\,W\,u_1 . + u_2\;)}{(a\,x + b)^2} = 0$$

or

$$b\,[(n\,W - x)\;u_2 - (m\,W\,u_1 + u_2\,x)] - a\;(n\,W - x)\;(m\,W\,u_1 + u_2\,x) = 0$$

Expanding these terms

$$\left.\begin{array}{l} b\,[(n\,W - x)\;u_2 - (m\,W\,u_1 + u_2\,x)] + a\;(n\,W - x)\;u_2\,x - a\,m\,W\,u_1\,x \\ \qquad - a\;(n\,W - x)\;u_2\,x - a\,u_2\,x^2 \\ \qquad - a\;(n\,W - x)\;m\,W\,u_1 + a\,u_2\,x^2 \\ \qquad + a\,n\,W\,u_2\,x \end{array}\right\} = 0.$$

Reducing terms and collecting

$$b\;(n\,W\,u_2 - m\,W\,v_1) - a\,m\,n\,W^2\,u_1 + a\,n\,W\,u_2\,x - 2\,b\,u_2\,x = 0$$

and

$$x = \frac{a\,m\,n\,W^2\,u_1 - b\;(n\,W\,u_2 - m\,W\,u_1)}{v_2\;(a\,n\,W - 2\,b)}$$

Where

$$a = \tfrac{11}{3} . c_1 + \tfrac{8}{3} . \tfrac{77}{23} . c_2 - c_3$$
$$b = (9\,h + 8 . \tfrac{77}{23}\,c_2)\;m\,W + c_3\,n\,W$$

the term due to the carbon heated $[c''\;(n\,W - x)]$ being here included in $(a\,x + b)$.

There is, therefore, a certain proportion of the carbon in any gas, which, if it be left free for ignition, emits a more intense light than any other proportion. This explains the intensifying action of certain hydrocarbons, with the vapours of which ordinary coal gas has been recently enriched. The mass of ignited matter is greater, and the temperature also is increased. I am not without hope that, before long, I may be able to make an important application of the principle herein demonstrated.

NOTE.—The influx of air required to burn the hydrogen and the carbon may be thus computed:—If we denote the carbon by c (the value of x above determined), we may suppose W to be the weight of gas delivered in 1 second of time. The pressure p is known, as also is that of the external air (though the latter will be rarified after the combustion begins). From this the velocity v of influx of the gas may be found by a well-known formula; and the area of the orifice or jet w also being known, we have $W = g\,d\,w\,v$ (g the force of gravity, and d the density of the gas, that of air being 1). Thus air containing $\frac{23}{100}$ of its weight of oxygen, we have—

Weight of air due to the hydrogen m W	$= \frac{100}{23} . 8\,m\,W$
Weight of air due to c of carbon yielding carbonic acid gas	$= \frac{100}{23} . \frac{16}{6} . c$
Total weight of air	$= \frac{100}{23} . (\frac{16}{6} . c + 8\,m\,W)$

This turned into volume at the rate of 1·2 oz. to 1 cubic foot, gives the volume of air required per second of time. It is supposed that no other air than this is to be admitted to the flame after its ignition.

FRANCIS CHARLES KNOWLES.

Mayfield, Ryde, 20th May, 1879.

THE "INOXIDATION" OF IRON.

May I address a few queries on the paper, read on March 27, on the "Inoxidation of Iron," and reported in the *Journal* for April 18?

"Cast iron articles . . have their fibre irretrievably deteriorated" (p. 443). Has cast iron a fibre? And does a sample of fibrous iron lose its fibrous texture on exposure of its exterior surface to acids?

"Pores of the iron" (*ibid*). What are they? What will happen if "homogeneous adherence" to the pores of iron is brought about?

What are the reactions that take place in the processes? Are there any? Are the molecules of platinum welded to each other, or do they exclude "pores?" Has the process no theory?

"According to the thickness of the iron so was the heat required, varying from 400° to 1,000°" (p. 446). Why were these limits not stated in the paper? If the process is completed by getting a surface-heat merely, why is the thickness of the iron to be taken into account?

"On polished steel the platinum would adhere with a less degree" (*ibid*). Less than what? Has polished steel a "porosity" superior to that of cast iron? What is the test of adherence?

"They had a stove in use in Paris all the winter . . . the invention was a novelty, [and] they could not give a longer experience." Is a foreign process a novelty in 1879 which was patented in England in July, 1876 (see spec. No. 2,971, A.D. 1876)? Is there any or no French patent?

"The method of applying platinum to . . ceramic substances was discovered by M. Dodé's grandfather, and carried out by him seventy years ago." Is this a proof of the novelty of the invention? And why does the specification claim glass as well as iron?

I have seen a Paris-prepared specimen badly rusted by a night's exposure, and the platinum coating of another specimen cleared in a few minutes by treatment with nitric acid.

E. GROSVENOR.

Woodlea-road, N.

A NEW PROCESS IN METALLURGY.

With reference to the discussion that took place on the 30th ult., and to Mr. France's statement that the crude sulphur he received contained 47 per cent. of sulphur, 24 per cent. of siliceous materials, and 28 per cent. of oxide of iron, I have just received from Mr. J. T. Merry, of Swansea, an analysis of the crude sulphur obtained at the experiment on the 8th April last, and which he sampled:—

Certificate of Analysis of Crude Sulphur.

Assay Office and Laboratory,
Mining Offices,
Swansea, May 23, 1879.

I herewith hand you my analysis of the sample of crude sulphur taken from Cupola B, Atlas Works, Sheffield, the 8th April, viz.:—

On Crude Sulphur dried at 100°.

Sulphur	63·30
Silica	7·00
Iron	2·76
Arsenic	7·12
Lead	8·95
Zinc	2·74
Copper	trace
Lime	trace
Magnesia	trace
Alumina	trace
Oxygen	trace
Carbon and loss	8·13

(Signed) JAMES T. MERRY.

To John Hollway, Esq.,
London.

Your readers will notice that the proportion of silica and iron found by Mr. Merry is much less than stated by Mr. France, and the reason is very simple. The crude sulphur Mr. France received from Messrs. John Brown and Co's. works contained, mixed with it, some of the *debris* resulting from the jet of water in the condensing cupola B, washing down the old materials from the sides of the cupola which had been out of use for a considerable period. JOHN HOLLWAY.

Jeffery's-square, St. Mary Axe,
London, E.C., 27th May, 1879.

TUSSER SILK.

I see in the *Journal of the Society of Arts* for May 9th, mention is made by Mr. Francis Cobb of the French so-called "secret" for dyeing Tusser silk. I believe it to consist simply in the application of binoxide of barium to the bleaching and "decreusage" of this silk. The invention is one of the emanations of the fertile brain of Monsieur Tessié du Motay. I showed the process to a few friends some time since, in the laboratory of King's College, which was kindly lent to me for that purpose. After this treatment, the Tusser seems to take all colours with the same facility as the ordinary silks, even the richest blacks. The process is largely employed in both Lyons, Basle, and other places on the Continent.

F. MAXWELL LYTE.

Jarrow Chemical Works,
South Shields, 16th May, 1879.

PUBLIC WORKS IN INDIA.

The amount to be applied for public works in India in the next financial year is £2,500,000. Two million five hundred thousand pounds is a large sum. According to my reckoning, this makes two annas per head for each man, woman, and child in India; that is to say, 2d., 2½d., or 3d. each, at the outside, to provide an outfit of public works. Two pennyworth of railway is not a large amount, but if the people indulge in two pennyworth of railway, they cannot have two pennyworth of irrigation, nor, of course, one pennyworth of harbours. It is a matter of serious consideration whether such a course of finance can develop the resources of India, or increase its revenues.

HYDE CLARKE.

NOTES ON BOOKS.

The Story of Mozart's Requiem. By William Pole, F.R.S., Mus. Doc. Oxon. London: Novello, Ewer, and Co. 1879.

The author of this little book agrees with the elder Hiller, who expressed his opinion that the Requiem is "the greatest of all works, by the greatest of all masters." As is generally known, Mozart left his work in an incomplete state, and desired that it should be completed by his pupil, Süssmayer. The composer's widow placed it in his hands after having previously applied to various musicians to complete the work, one of whom—Joseph Egbler—chief of the orchestra at Vienna, actually entered into an agreement to finish it, but afterwards broke his engagement. Dr. Pole, after an earnest endeavour to arrive at some discrimination between what is and what is not to be ascribed to Mozart, is content to give up the problem as insoluble.

Conseil General de la Seine. Commission Spéciale des Chemins de Fer et Tramways. Contre-projet de Réseau Urbain du Chemin de Fer Metropolitain présenté par M. E. Deligny. Paris, 1879.

Mons. Deligny, after pointing out that the capabilities of omnibuses and of tramways are limited, and, therefore, that an underground railway, such as we have in London, is a necessity, attempts to show the advantage of the lines that he sketches out over those proposed by the Commission. One of the chief points upon which the author lays stress, is the need for extending the railway through the Bois de Boulogne to Neuilly. He has added to his pamphlet a series of maps of Paris, upon which are marked the lines as proposed in the various schemes.

Report on Miscellaneous Old Records of the India Office, November 1, 1878. London (Eyre and Spottiswoode), 1879.

This report, which has been drawn up by Dr. Birdwood, C.S.I., contains an account of the papers formerly belonging to the old East India Company, but now deposited at the India Office. The papers have been arranged under the following five main headings:—1, Court Minutes, and Legal and Miscellaneous Affairs of the Company; 2, Trading and Shipping; 3, Foreign Relations; 4, History of the Company in India; 5, Factory Records. Dr. Birdwood finds every scrap of these papers to be of some interest and importance. The second portion of the report is entitled, "Note on the Discovery of the Passage to India by the Cape of Good Hope, and on the early Settlements of the European Nations in the Eastern Seas," and is accompanied by two maps, showing (1) European discoveries made in the quest of India, and (2) early European agencies, factories, and settlements in the Indian seas. The substance of this report was read by Dr. Birdwood as a paper before the Indian Section of the Society of Arts, on Friday, January 31, 1879, and was printed in the *Journal* (vol. xxvii., p. 193).

Reports on the Carriages in the Paris Exhibition, 1878, with Appendix. Edited by Charles Saunderson. London (Hardwicke and Bogue), 1879.

Mr. Saunderson, the late Master of the Company, has published the reports sent in by the artisan reporters specially selected for the duty by order of the Worshipful Company of Coachmakers and Coach-harness Makers of London. In all there are five reports, dealing with the following subjects:—1. Coach-body making; 2. Wheels and under carriages; 3. Coach smithing and springs; 4. Trimmers' work; 5. Painters' work; and a sixth, a supplemental report, which treats of exterior ironwork fittings, interior fittings, lamps, plating and beading, chasing, and wood carving. To the reports are added several appendixes, the first four of which treat of—1. Import and export of carriages, 1856, 1866, 1870; 2. Labour in constructing a carriage; 3. Awards to British coachbuilders, Paris, 1878; 4. London drawing class for coach artisans, while the last three are devoted to information upon what the editor considers kindred topics. Thus, the fifth refers to the National Wood Carving School, the sixth dea

with the Science and Art Department (Schools of Art), and the seventh and last gives an abridged prospectus of the Society of Arts. Finally, there are some "addenda" devoted principally to matters connected with the Coachmakers' Company and the Coachbuilders' Benevolent Institution.

NOTICES.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

SANITARY CONFERENCE.

The Pamphlet containing the full report of the papers and proceedings of the late Conference on National Water Supply, Disposal of Sewage, and Health, will be published shortly, price 2s. 6d.

Applications for copies of the Report should be addressed to the Secretary.

PROCEEDINGS OF THE SOCIETY.

Adjourned Meeting.

The adjourned Meeting for the conclusion of the discussion of the Paper by Mr. Lloyd Wise, on "The Government Patent Bill," will be held on Tuesday, the 10th June, at 8 o'clock.

THE LIBRARY.

The following works have been presented to the Library:—

Minutes of Proceedings of the Institution of Civil Engineers. Vol. 55. Session, 1878-79—Part 1. (London: 1879.) Presented by the Institution.

Conseil Général de la Seine. Commission Spéciale des Chemin de Fer et Tramways. Contre-projet de Réseau Urbain du Chemin de Fer Metropolitain. Présenté par M. E. Deligny. (Paris, 1879.) Presented by Lord Alfred S. Churchill, Chairman of Council.

The following have been presented by the Local Government Board:—

The 1st to the 7th Annual Report of the Local Government Board, 1871-1877. (London: 1872-7.)

Supplement to the 6th and 7th Reports, containing the reports of the Medical Officer for 1876-7. (London: 1878.)

Reports of the Medical Officer of the Privy Council and Local Government Board, 1873-5—new series. (London: 1874-6.)

Sewage Disposal. Report of a Committee appointed by the President of the Local Government Board to inquire into the several Modes of treating Town Sewage, with plans. (London: 1876.)

Official Copy. Public Health Act, 1875. Suggestions as to the Preparation of District Maps. Revised to 1878. (London: 1878.)

Dr. Blaxall's Report on Diphtheria in Plymouth, 1878.

Dr. Airy's Report on the Water Supply of Atherstone and Polesworth, 1878.

Mr. W. H. Power's Report respecting a Special Mortality among Infants, 1878.

Dr. Airy's Report on the Sanitary State of part of Burton-on-Trent, 1878.

Dr. Airy's Report on the Sanitary State of Knighton District, 1878.

Dr. Airy's Report on Diphtheria in Battle District, 1878.

Dr. Airy's Report on Diphtheria in parts of Wrexham District, 1878.

Mr. J. N. Radcliffe's Report on the Sanitary Condition of Tredegar, 1878.

Dr. Thorne's Report on the Sanitary Condition of Dewsbury, 1878.

Mr. W. H. Power's Report on Diptheria in North London, 1878.

Model Bye-laws for the Use of Sanitary Authorities. Parts 1 to 8. (London: 1877.)

Public Health Act, 1875, Model Bye-laws. Two Letters to Clerks of the Rural Sanitary Authorities, and one to the Clerks of the Urban Sanitary Authorities, dated 25th July, 1877.

MEETINGS FOR THE ENSUING WEEK.

Mon., June 2nd...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Karl Hillebrand, "The Intellectual Movement of Germany from the Middle of the Last to the Middle of the Present Century." (Lecture IV.) 5 p.m., General Monthly Meeting.

Tues., June 3rd...Royal Institution, Albemarle-street, W., 3 p.m. Professor J. R. Seeley, "Suggestions to Students and Readers of History." (Lecture III.)
Biblical Archæology, 33, Bloomsbury-street, W.C., 8½ p.m.
Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. W. Ottley, "A Description of the Vessels of the Neck and Head of the Ground Hornbill." 2. Mr. E. R. Alston, "The Specific Identity of the British Marten Cats." 3. Messrs. Sclater and Salvin, "Birds collected by the late Mr. T. K. Salmon in the State of Antioquia, U.S. of Colombia."

Wed., June 4th...Entomological, 11, Chandos-street, W., 7 p.m.
Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Rev. S. M. Mayhew, "Further Discoveries at Lincoln." 2. Mr. C. H. Compton, "The Horners' Company of the City of London." 3. Mr. J. T. Irvine, "The Course of the Wansdyke, near Bath."
Obstetrical, 53, Berners-street, Oxford-street, W., 8 p.m.

Thurs., June 5th...Linnean, Burlington-house, W., 8 p.m. 1. Mr. C. B. Clarke, "Ferns of Northern India." 2. Prof. W. K. Parker, "Structure and Development of Skull of Urodelous Amphibia." 3. Prof. H. M. Fries (of Upsala), "Lichens of English Polar Expedition, 1875-76." 4. Rev. R. Boog Watson, "Mollusca of *Challenger* Expedition."
Chemical, Burlington-house, W., 8 p.m. 1. Dr. Stenhouse and Mr. Groves, "On Eardenine." 2. Mr. F. D. Brown, "The Theory of Fractional Distillation." 3. Mr. F. R. Japp, "The Action of Organozinc Compounds on Quinones." 4. Mr. J. W. Mallett, "On Chlorstannic Acid." 5. Mr. E. Schunk, "On Indigopurpurin and Indirubin." 6. Dr. Wright, Mr. Luff, and Mr. Rennie, "Report to the Chemical Society on Some points in Chemical Dynamics."
Society for the Encouragement of Fine Arts, 9, Conduit-street, W.
South London Photographic (at the House of the Society of Arts), 8 p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. R. Seeley, "Suggestions to Students and Readers of History." (Lecture IV.)
Archæological Institution, 16, New Burlington-street, W., 4 p.m.
Inventors' Institute, 4, St. Martin's-place, W.C., 8 p.m.

Fri., June 6th...Royal United Service Institution, Whitehall-yard, 3 p.m.
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Paper by Prof. Dewar.
Geologists' Association, University College, W.C., 8 p.m.
Philological, University College, W.C., 8 p.m. Mr. Henry Sweet, "The Laws of Stress in Compounds and Sentences in English."

Sat., June 7th...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Henry Morley, "Swift." (Lecture III.)

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,385. Vol. XXVII.

FRIDAY, JUNE 6, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

GENERAL MEETING.—ALTERATION OF BYE-LAWS.

The Council hereby convene a General Meeting of the Members, for the purpose of altering, varying, and revoking the existing Bye-laws of the Society, and making new and other Bye-laws in the place thereof, such meeting to be held on Monday, the 16th day of June, at four o'clock in the afternoon. (By Order of the Council.)

H. Trueman Wood,
Secretary.

3rd June, 1879.

CONVERSAZIONE.

The Society's *Conversazione* is fixed to take place at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education) on Wednesday, the 25th of June. The cards of invitation will be issued shortly.

CONFERENCE ON NATIONAL WATER SUPPLY, SEWAGE AND HEALTH.

The proceedings of the Conference commenced on Thursday, May 15, the chair being taken by Lord Alfred S. Churchill, Chairman of the Council, who expressed his regret at the absence, through illness, of the Right Hon. James Stansfeld, M.P. (Mr. Stansfeld presided at the afternoon sitting.)

The Chairman read the report of the committee appointed to adjudicate upon the essays sent, in response to the announcement that the Council of the Society offered one gold and three silver medals, for the best suggestions for dividing England and Wales into districts, for the supply of pure water to the towns and villages in each district. None of the essays were considered worthy of the gold medal, but a silver medal was awarded to Mr. Frederick Toplis for his paper bearing the motto "Better Late Than Never;" and one to Mr. Joseph Lucas for his paper with the motto "Gutta cavat lapidem, non vi, sed sæpe cadendo."*

* The report and the conditions of the offer were printed in the last number of the *Journal* (p. 571.)

He then called on Mr. Toplis, Mr. Lucas, Mr. Goslin, Mr. Atchison, Professor Ansted, and Mr. Birkett, successively, to state the main points of their respective essays.

Mr. Lucas said he had long ceased to advocate horizontal wells. He was not an engineer, and had not pretended to do more than offer very general sugestions, founded not on his own observations, but on the theories of others. The moment he began to use a tape-line level, he assured himself beyond doubt that horizontal wells would not be at all desirable.

The Chairman then invited discussion on the various essays which had been contributed.

Mr. John Evans, F.R.S., felt that this subject was one of great importance to the country generally, and especially to those places where, at the present moment, the water supply was insufficient in quantity, or impure in quality. No doubt many of the suggestions made in these papers would add materially to the practical means of carrying out an efficient water supply throughout the kingdom. There could be no doubt that there should be some division into districts, and that there must be over the principal districts a certain number of Commissioners, or persons in authority, who would act in accordance with the Local Government Board. It appeared to him that the Board must be the central authority under which all these minor bodies must be placed, but what he wished more particularly to point out was this, that as the law at present stood, there were many difficulties in carrying out any scheme of this kind generally throughout the kingdom. In the first place, there was the enormous cost which would be entailed on any Government which undertook to lend a sufficient amount of money for carrying out the water supply for the whole country. That raised a second question, how far it would be desirable to supersede existing water authorities by purchasing their works. It did appear to him that there were three distinct classes of places requiring water supply: first of all, the large towns, in most of which an efficient supply existed, either the property of the corporations, or in the hands of private companies; secondly, there were the smaller towns, in a great number of which private companies had started, who were supplying the inhabitants at a moderate amount of cost; they had found the capital, and it appeared to him in most cases it would be needless for that capital to be taken over by parishes, and thus add to the amount of money necessary to be borrowed for purposes of this kind; thirdly, there were those small country villages, where the population was sparse, and where in many cases the water supply was not wanted so much generally, as in particular instances. In order to obtain a water supply in a country district lying at some distance from any gathering ground or good source of supply, the amount of capital necessary to lay out in works amounted to so large a sum, that any rate on a district supplied fell almost too heavily upon it. There were always a certain number of houses in which there was a sufficient supply, and the owners objected to being taxed for the benefit of their neighbours. The principle hitherto adopted by the Local Government Board was, that where the water supply was required for the central portion of a parish, the rates should extend over the whole parish, land being taxed at the rate of one-fourth the amount of house property. That had on the face of it a certain amount of fairness, but practically it was not fair in a great number of cases. Where there were in a parish various centres of population, some of which were already amply supplied with water, it was very hard that they should be taxed for the supply of one-third or one-fourth of the population which was in want of it. Again, the incidence of taxation was by no means fair. He knew a case in his own neighbourhood, where a scheme was proposed. Among the ratepayers

was the occupier of a water-mill, who was rated at £400 a year, and the rate upon him would be the same as if he occupied a mansion at £400 a year, and required a large amount of water; but practically he did not want a drop, and he said so long as the principle of taxation is so thoroughly unfair, he should object to any scheme of the kind being carried out. He wished rather to point out the difficulties which existed, than to argue the general question, and this was a feature of considerable importance. It seemed to him that the area of taxation need not extend over a whole parish, but might be limited, either for water supply or sewage purposes. That area should, in the first instance, be taxed, and if the rates for sanitary purposes exceeded a certain amount, the residue should fall on the remainder of the parish. He could not but think that some such scheme as that would be beneficial in many respects, and would remove one of the difficulties that stood in the way of obtaining a water supply. But there was another ground on which opposition was raised, and that was the utter want of equity which seemed to prevail in the mind of those who organised water schemes. He need only refer to the great scheme brought forward by the Metropolitan Board, which to his mind showed a complete want of appreciation of the ordinary principles of moral equity. They applied not only to purchase the property of existing water companies, but were also going to lay out an enormous sum in procuring the supply in duplicate. From whence? From the chalk districts around London, the water of which was already appropriated; but they were not prepared to make any compensation to the owners of the rights in the water which they were about to remove; so that, practically, it came to this, that they claimed the right to sink a well in porous soil by the side of a river, to lay the river dry, and to pay no compensation whatever for the abstraction of the water. If schemes so utterly wanting in ordinary equity were brought forward, we could not be surprised at a great deal of opposition being raised. It appeared to him that existing rights, whether in rivers or springs, or any water which arose from perennial springs, must be considered, or else an amount of opposition would be raised which was quite unnecessary. If the schemes brought forward were founded on equitable principles, no one in these chalk districts could possibly object to the use of the water for the supply of the inhabitants of the neighbourhood, for it mattered not whether it was taken direct from the river or from a series of wells, but directly it was proposed that this water should be taken and carried away to a distance, and sold at a profit to somebody else without any compensation being given, everyone's feelings were aroused against the injustice, and opposition was created.

Professor Ramsay, F.R.S., being called upon, said he came quite unprepared to speak, although he had given a great deal of attention to the subject, particularly to drainage areas, the qualities of the waters of different rivers, and also to the question of these large underground supplies of water which could, in many places, be obtained without touching the river waters at all. Mr. Evans had broached a number of matters of detail which no one could come to any conclusion about now, except as to the abstract principles of justice he had mentioned, and which would necessarily have to be borne in mind if any great scheme were carried out for the supply of water. Then all the different drainage areas of England must of necessity be taken into account and treated with in some equitable manner. He knew the various drainage areas of England well, and some 20 years ago had constructed a map showing those areas in relation to the geological formations of each. He had no doubt that if ever a large comprehensive scheme were formulated, and after having been well thought out, were brought into action or recommended, England must in the main be divided into given areas of drainage more or less connected with the various towns and villages lying within those areas. Any geological map would show that in the South of England, east of Devonshire, and over almost all the half of England, up to Durham and Northumberland, the formations were calcareous to a great extent, and the result of that was that nearly all the rivers that ran into the German Ocean and English Channel east of Devonshire were more or less hard in quality; but it did not necessarily follow that the water was essentially bad. If it were possible to get soft water into those areas, it would be desirable, but if it were impossible to do so at a moderate expense, then the people who lived in them must do the best they could with the water they had. One gentleman had alluded to the soft waters of the Cumbrian district, and he was perfectly correct. The rocks there are partly slates and grits, but a very large part consist of feldspathic traps and volcanic ashes, the water which came out of which in springs was always of a soft, pure quality. He also said that the waters of Wales were, as a rule, hard, but he begged leave to differ from him in that respect. He did not think there was anyone in the British Isles better acquainted with Wales than himself, for there was not a mountain he had not been on, and either personally surveyed or superintended its survey. It nearly all consisted of silurian slates and igneous rocks, and all the rivers which flowed eastward were soft in quality. Here and there there were impurities resulting from mines, but not to any very great extent. In one place in Cardiganshire, the waters had been rendered impure by the crushing of lead ore, and the refuse ran into the rivers to such an extent that the fish were poisoned, but these were rivers which all flowed to the west into Cardigan Bay, and would not be wanted for the supply of water anywhere to the east of the great water-shed of North Wales, which ran north and south no great distance from Cardigan Bay. The water that ran out of the old red sandstone was somewhat harder, but that all drained into the Severn or its estuary, and the same was the case with the water from the coal measures. If any large supply of water were wanted from Wales to supply London, or any other towns to the east, an ample supply could be obtained from those deposits, soft and agreeable in quality. There was another grave point with regard to wells that might be sunk into underground supplies of water, though it would be useless to go into that matter thoroughly unless he had two or three hours to do it in, and geological maps. He would simply say this, that there were great areas in England where vast quantities of water could be obtained if tapped judiciously. He saw before him Mr. Bright, late Mayor of Leamington, who had had a deal of experience on that point, a well having been sunk there by Mr. Ramsay's advice in the keuper sandstone, and now the township was supplied with four times as much water as was required. He was also connected with the supplying of Brighton with water. They stopped sinking three times, but he insisted on their going on until they pierced the lower greensand. They went on, and it was very fortunate the men were all at dinner, when a thin stratum of gault having been left above the greensand, the water suddenly burst up and filled the well, and would have drowned them all had they been there. These supplies could not be obtained everywhere, but in many places they could, and were of very great importance.

Mr. G. J. Symons, F.R.S., said there could be no doubt of the desirability of adopting some general scheme instead of the present scramble, in which it was simply a question which was the richest town and the most reckless, because the most bold and ambitious went to Parliament with a great scheme, having made up their minds to get water from somewhere or other. If they found there was any opposition in the district, they simply bought it off, and then they were like Manchester in possession of Thirlmere, whether or not it was a wise thing for the water to be appropriated to that particular town. Parliament had no adviser on the

subject, but simply took the evidence brought before it in the Committee-room, and if that were all on one side, the Bill was forthwith passed. So it happened this year. The local opposition to the Thirlmere scheme had been bought off, and the question whether it was wise for one of the great national supplies to be appropriated almost exclusively to one town, instead of some broad, general, comprehensive scheme being adopted for the benefit of the whole of the North of England, that being a pure piece of public policy, did not come before Parliament at all. The consequence was, the Committee found the evidence all on one side, and Thirlmere, for all time to come, became the absolute property of Manchester. He could not think that that system was right; surely it would be an enormous benefit if there were some Court of Reference, or some authority who should be independent of the personal interest either of Manchester, Liverpool, or any other town, and should say whether it would be wise and right that the great stores which exist in two or three comparatively small localities should be wholly devoted for all time to one town, because as soon as the water supply was given to one town it was their property for ever; and if any intervening town wanted a supply in future from the Thirlmere district, Manchester would expect to be paid very handsomely for its present investment. The meeting was probably aware that the great bulk of the rain fell in Cumberland, Westmoreland, and North Wales. He quite agreed with Professor Ramsay that, practically, there was no difference between the water of the two districts; but that being the case, one ought to look at the fact that there were a large number of towns in which the populations and growth were rapidly increasing, and, consequently, the consumption of water. The bulk of the water practically came from one district, although at Dartmoor and one or two other places there might be a certain amount; but the bulk of the supply was all in one corner of the country. Now of these Cumberland lakes there were only three of any size, which were high enough to supply the greater proportion of the country without the extra cost of pumping, and if you had to lift the water, the expense would be very much increased even at the present time, and much more so in the future when coal became scarcer. There were then only three lakes sufficiently elevated to supply water by gravitation, namely, Thirlmere, Ulleswater, and Haweswater. Thirlmere was already bespoken by Manchester, and it was pretty well understood that Liverpool intended to get Haweswater. If they did, there would be less water left for all the large manufacturing towns, of Yorkshire and all the remaining towns of Lancashire. If these two most important lakes were taken away, there was a very small residue left behind. He could not think this was a state of affairs which would be contemplated with satisfaction in 50 or 100 years time. It was merely a question of expediency that some arrangement should be made by which the public aspect of this question should be put before Parliament separately from the private one of the particular towns which wanted the supply, or the landowner who asked for compensation for the water taken. There was one grand difficulty in connection with this subject, and this was the very large amount of pecuniary interests already involved. Mr. Evans was perfectly right when he said that it would be a most frightful undertaking for any Government to buy up all existing companies. No one knew how many millions of money that would take, and there was a great difficulty in the way of the introduction of any scheme. As the author of one of the papers remarked, it would be very easy to arrange for a water supply if they could only begin *de novo*; but the question was to get something which would work into existing arrangements without disturbing them more than necessary, but which would prevent in future any town snatching a mean advantage over the rest. Another thing which perhaps had done some mischief was the map in the report of the Rivers Pollution Commission showing the polluted rivers of England. It had frightened a good many people, and he must confess his own opinion was, that it was one of the most exaggerated maps he had ever seen. If a partridge flew over a moor, you might say that a river flowing through that country was polluted to some extent, and he was inclined to think that some of the pollutions indicated on the map would not be more serious than arose from the sheep-droppings on the hills. Another remark in the 6th Report of the Commission was to the effect that rain-water was bad, that it had washed the air of all its impurities, and had done all sorts of things. He should not like to drink London rain-water; but still rain-water generally was soft and pure, and he was sorry to see this slur cast upon it. There was also a proposal made that this class of questions should be put under the Local Government Board. He did not pretend to know much about it, but he believed that the Local Government Board already had a tremendous amount of business under their charge, and he was inclined to think that this was too large a question to be put in a secondary position of that sort. At the last meeting of the Social Science Congress, Dr. Richardson suggested the appointment of a Minister of Health, and he could not help thinking that what they wanted was, the creation of new appointments in the Cabinet from time to time, in accordance with the growing wants of civilisation, because they had simply the same officers now as they had 100 years ago. The French had a Minister of Public Instruction, but they had none. This question of water supply was, to a great extent, connected with public health, although it was also a question of commerce, and he thought it would be very well if it could be placed under the care of a Minister of Public Health. What he principally desired to insist upon was, that something or other should be done to provide a central focus in which all the statistics bearing on this question could be collected together. They had had Commissioners without end, who made reports in endless variety, but no one knew where to look for the information collected, except it was to the valuable collection published by the Society of Arts, for which he felt greatly indebted to it. If this information were all collected, persons would be much better able to deal with this question of water supply than they were at present. He was glad to find that this meeting was entitled an annual Conference, and he hoped that the Society would keep at it till something definite was done.

Mr. Bright (Leamington) said he would narrate the facts which had occurred in that town to prove that there was a very large underground water supply, which might also exist in many other districts, and which might be a large factor in this question. He was rather alarmed when he heard one of the previous speakers propose that the whole of this country should be divided into districts, which should be supplied at the general cost of the whole of the inhabitants, because many had gone to a large expenditure for the purpose of getting a water supply, and it would appear manifestly unjust if they were to be taxed equally with those who had done nothing at all. In Leamington they prided themselves on being rather in advance of the public generally on most questions, but especially on the water question. Like many other towns, they were suffering from the pollution of the small river from which they used to obtain their supply. When he went to Leamington forty years ago, the brook was very pure, but modern civilisation had gradually progressed up the whole of the water-shed, and the riparian proprietors higher up were adopting modern conveniences, and used the brook from which they got their water supply to get rid of their sewage. The result was that things got gradually worse and worse, until the absolute existence of the town as a sanitary resort was in great danger. They were indebted to

Professor Ramsay for an entire change. With the greatest possible kindness, that gentleman gave him the information he had collected in the Museum in Jermyn-street, and which he was always ready to give to any one in want of it, and, acting on that, in spite of the most persistent opposition from ignorant people, they bored for a short distance into the earth in the new red sandstone, and found a perfect river of underground water. Owing to the people having to be educated gradually, they had been some six or seven years about it; but during the whole of that time, supported by the advice and assistance of Professor Ramsay, they had gone on until, three months ago, they opened the waterworks to the public with the following results:—They found the water at about 100 feet; they bored another 100 feet by an artesian bore, but from that they did not get much. The largest supply was got within 110 feet from the surface. For the town of Leamington they required half a million gallons per day, allowing 25 gallons per head; but they found they could pump two and a-half million gallons without ever getting the well within 16 feet of the bottom; in fact, in endeavouring to get to the bottom for the purpose of ascertaining that everything was properly done by the divers, they had been pumping more than three million gallons, but they had not succeeded in reaching the bottom, the fact being that the more they pumped the more water they got. The reason of this was that the fissures in the rock got cleaned out, and the water came in with greater rapidity. No doubt there were many other districts equally well situated if they only knew it, and he should recommend any one who thought they had water beneath them to obtain the advice of Professor Ramsay upon it.

Capt. Douglas Galton, C.B., F.R.S., said he had read all the papers sent in very carefully, and the suggestions made were certainly of very high value. He regretted they had not been more fully alluded to; indeed, many of the speakers did not seem to have made any allusion to them. One gentleman recommended that the rivers themselves should be taken as the boundaries of districts, with which he certainly did not agree, but there were other points of merit in the paper worthy of attention. The whole question, however, seemed to him now to have come to a focus, and everyone concurred in admitting that England should be divided into districts of some sort for the purpose of regulating the water supply. There might be differences of opinion as to how those districts should be constituted. There was also a general consensus of opinion on another point, namely, that the information which existed should, as far as possible, be brought to a focus. It was quite clear that a very large portion of the information rested in the hands of the Geological Survey Department, and probably there was no one who had a greater knowledge of the geological questions affecting the water supply in this country than the present Director-General of the Survey, Professor Ramsay. There were other departments which were strictly concerned with this matter, but now they were all scattered about. The Local Government Board seemed to be the legitimate focus for this information, and whether the Minister of Health were to be appointed or not, at all events that Board must be the framework on which the Ministry of Health would be hung. It seemed to him that the most sensible thing to do, as a preliminary step, would be to place the Director-General of the Geological Survey, the Director of the Ordnance Survey, the Registrar-General's Department, and a department for recording the rainfall, in official relation with the Local Government Board, so that, at all events, all the Government departments which had information bearing upon this question, and upon questions relating to the health of the community, might all be brought into immediate communication under one minister, who could thus easily organise a machinery for collecting and diffusing information upon questions relating to water supply. The Ordnance Survey was originally devised as a military department, for the making of a military map of the country, but as soon as that was completed, the War-office, not liking to bear the cost of it, tried to get rid of it; and, the only department they could think of transferring it to was the Office of Works, which is now, of all others, the one least suited for the purpose, seeing it has nothing to do with anything outside London, except perhaps the building of a few post-offices, and there is no one in that department who has any special knowledge of a matter like the Ordnance Survey. It would have been, therefore, far better to have transferred it to the Local Government Board. Although the Local Government Board was so much found fault with, he believed it was the department which must eventually have charge of all these matters. Parliament was at present concerned with a Bill for the river conservancy, and as Mr. Atchison had remarked, river conservancy and water supply must go hand in hand. Whether the water was got directly by pumping from underground, or percolated by the overflow of those underground waters into the rivers, it all came from the rainfall, and, except in cases where large aggregations of population exist, as, for instance, London and Manchester, and where, therefore, the requirement might exceed the available local supply, districts should be so arranged as to be self-contained in regard to the control of their water supply and drainage; each district must consider for itself what are its own wants, and arrange for their supply.

The Chairman suggested that the Conference should now go into the general question of supply of water in connection with the health of districts, and he would ask gentlemen who had written papers on the subject to state the substance of them.

Mr. A. H. Brown, M.P., having stated the substance of his paper on "The Incidence of Rating for Sanitary Purposes in Rural Districts,"

Mr. J. Evans said that he had not seen Mr. Brown's paper previously to making the remarks he had offered that morning, or he should not have gone over much the same ground, for which he must apologise. At the same time he must express his satisfaction that a gentleman who had given so much attention to this important question had so far agreed with him.

Mr. Edwin Chadwick, C.B., expressed his concurrence with the idea expressed by Captain Galton, that the various administrative departments in any way connected with this subject ought to be brought under one head. The further you went the more you found the necessity of centralising authority and centralising knowledge in this direction, and such knowledge as was brought forward on that occasion would be of immense value to the country. The great obstacle to reform in this matter had been touched upon by Mr. Evans, viz., the question of the purchase of various interests, and one important function of any general Board, besides centralising knowledge and authority, would be to adjudicate between rival interests as to questions of compensation. That was now going on to some extent under the Local Government Board. The tendency in very large places was to place water supplies under public authority, to put them on a footing in which payment should not be made for a trading profit, but for a service rendered. Before that could be brought about no doubt companies and private enterprise were very serviceable, and he himself had promoted private companies for water supply. The Local Government Board had been adjudicating on questions of compensation between owners and towns, and it had been, on the whole, he believed, done in a manner satisfactory to both parties, and was generally carried on voluntarily. It was a great misfortune that the principle had not yet been brought to bear, as it ought to be, in the case of the metropolis. The obstacle there was the question of purchase, which was to be settled by

some sort of arbitration or judicial intervention, and that ought to have been done a long time ago. The truth was, the Metropolitan Board of Works seeing nothing done by the Government, thought it only right on its part to make an effort to do it, and although it had not been successful in getting a good plan, he thought himself it was very unfair to surcharge the individual members of that Board heavily for an effort which was very good in itself, although it might have failed. One ground for putting this water supply on a public footing was, that it might bo carried out far better and cheaper than it could possibly be by a company. Companies could not have eontrol over interior works, and the means of carrying the water away; but both ought to be under one authority, and that should be a public one. It was lamentable that whilst that was the general tendency, and the results generally were satistactory, the metropolis should remain an exception. It had been referred to Dr. Farr and himself to examine as to the terms of purchase, and they found the amount of waste from separate works would be equivalent to a rate of 6d. in the £, and that if the companies were bought up now at the rate they claimed for themselves of 10 per cent., it would not amount to more than a rate of one-third; whereas by the stream of decisions of the Local Government Boards throughout the country, it would not amount, if adjudicated upon on the same principle, to more than one-sixth of the waste now going on. A central Board eould only act on the Local Government authority, but there was a great want of scientific knowledge in the localities, and he himself had contended for putting not only the roads, but the water supply of a county, under a county engineer, as had been done in Ireland with great advantage.

Mr. W. H. Wheeler then stated the substance of his paper, on "The Water Supply of Rural Districts."

Mr. C. N. Cresswell asked permission to make a few remarks on the paper of Mr. Brown, which seemed to him to be of peculiar significance at the present moment, and he should not like it to pass without discussion. It would be a matter for great regret if a paper, which was the result of so much thought, experience, and well directed energy, were to be dismissed as if it were the crude expression of an uninformed opinion. He was so far disposed to agree with Mr. Brown, that he could hardly raise a discussion upon his paper; nevertheless, he would start a difficulty, for the sole purpose of enabling others to hang, as it were, one peg on another, and thus debate the question which, in his humble opinion, Mr. Brown had not exaggerated when he said it lay at the very root of that sanitary progress which they came there to discuss and promote. When Mr. Brown told them it was useless to eome there and speculate on theories or discuss methods unless they removed the obstacle which lay at the foundation of all progressive legislation, he struck a chord which ought to vibrate through the mind of every intelligent sanitary reformer. That great obstacle was simply this,—you could only effect sanitary improvements by means and money, by a taxation of the people, and unless you had a system of taxation based on equity and justice, all political and social action in this country became impossible, by reason of the prejudice which you created, and unless you could remove that moral obstacle you might as well try to remove mountains by mere faith. Mr. Brown told them that his experience showed that the inequitable incidence of taxation, particularly in rural districts, had for years past prevented that progress which all enthusiasts twenty years ago hoped to have seen. "Why," said one gentleman, "should I pay for the benefit of people living far away from me without benefiting myself in the slightest degree? I have already provided my house and those dependent on me with everything neeessary for their health and happiness. I have erected my own private gas works and water works, and in the middle of my park I have constructed an enormous cesspool which drains the houses and stables of those who live in my immediate vicinity. Why then should you make me pay for the benefit of a town which lies a mile and a-half away? It shows either that there is injustice at the bottom of the transaction, or that there is some original defect which needs redress in the arrangement of the sanitary area to which I belong." Now, the President of the Conference, whose absence they all deplored so much, had again and again called attention to the absolute necessity of a rearrangement of sanitary areas; and he would suggest to Mr. Brown, who was well able in the Legislature to make his voice heard, that that question also lay at the root of the matter, and that, if the sanitary areas were altered and rearranged with some degree of logical sequence, one of the difficulties to which he had alluded would vanish. In many cases, there were in one sanitary area two or three villages or hamlets, eombined under one rural sanitary authority without the slightest rhyme or reason, but by mere local or geographical accident. By altering that you would, to a great extent, remedy the evil, because you would make it impossible that one portion of the district should be made to pay for the exclusive benefit of another. Again, it was said that it was unjust that the agrieultural interest should be taxed for a benefit which they never could receive. He would submit to Mr. Brown that, in the Public Health Act, and in the incidence of rating established by Parliament, the interests of agriculture had been already considered, the land only paying one-fourth, because it was thought that the great cause of expense in these sanitary districts was the removal of sewage from dwellings; that it was the houses which, to a great extent, caused the mischief, and that on them should lie the expense of removing it; and, therefore, that on the land the taxation should be only one-fourth. Now, with regard to water rating, there could not be the slightest doubt that the principle advocated by Mr. Brown was logically correct, namely, that those who drank should pay; but when you came to drainage, you were met with this difficulty at the threshold—How far could you say that any person in a district or parish was left unbenefited by the improvement of drainage in the district? It would necessitate a department of health, and a total alteration in the system of rating, besides special commissions probably to do sanitorily, what had frequently to be done politically in ascertaining the boundaries of political boroughs. It would be found necessary, if this proposed readjustment were brought to maturity, to describe topographically, by parochial maps, every house, and the amount of contribution which each should pay, whether 100, or only 25 per cent. Then it must be recollected that although possibly in a particular parish or district the houses in the actual village profited more directly by any work of sanitation than those at a greater distance, nevertheless, the object of sewage removal was in almost all cases to prevent the pollution of rivers, and that those who might not be in any way contributing to the pollution were still benefited by the expenditure, which made the river that flowed through their own district pure above and below. Therefore, to lay down a proposition that they were not all within a certain area equally interested in the work done, opened the door to a great difficulty as to how far it was possible accurately to state, and, to decide the exact proportion between those who had to pay the whole, and those who claimed to pay less. He submitted these difficulties simply for the sake of raising an argument, because he thought Mr. Brown had eonferred an obligation on the meeting, and at any rate, that the paper should be discussed.

Dr. Tripe said the question of rating was one of extreme difficulty; the money question was at the bottom of it, because you could not expect persons, as benefactors to the public, to advance money unless they

could see a reasonable return for it. It would be simply impossible to expect a small village, where there were few houses, but with large building capabilities, to defray the cost of waterworks. It you laid the whole of the costs on those who first occupied the houses, what would you do with those who occupied the houses afterwards built on the same area, and partaking of the same advantage. Was it proposed that they who came afterwards should pay a smaller sum than those who were there first and assisted in the development of the water system? The same thing applied to drainage. Therefore, in order to provide the means for supplying water, it seemed to him that the rates must, at any rate, be chargeable, and if they were chargeable, then came the question how that was eventually to be defrayed. This seemed to be one of the great difficulties in carrying out Mr. Brown's proposal. The plan seemed equitable, and was equitable if it could be carried out, but he did not see how it could be done. He wished to speak, however, rather on the question of wells *versus* rain-water, which was one of very great importance. All medical officers of health and analysts who had had any experience knew that well-water was the most uncertain supply of all, unless the well was constructed with iron pipes or some impermeable tube, carried down below the first impermeable surface, the water must of necessity become contaminated with surface drainage. The capability of the soil taking out all noxious matters from the water was limited, if it were water-logged then the change could not go on, or only to a limited extent. The oxygen contained in the interstices of a porous soil not water-logged, acted on organic matter, and converted it into nitrates and nitrites, which were practically innocuous, and in that way you might get, for a length of time, well-water comparatively pure, but after a time, in consequence of continued rain, it got surcharged, the rain would carry with it a large quantity of surface matter, and the well suddenly became impure, and if typhoid excreta had been thrown on the soil, that found its way into the well, when disease occurred and spread. It was not confined to those who immediately partook of the water but spread everywhere, and in that way diphtheria, typhoid, scarlatina, and other diseases were diffused. The water in which scarlatina patients had washed might be a fruitful source of disease in this way. Milk also got contaminated from mixture with water, and this so-called milk was, he believed, a cause of typhoid epidemics; he did not believe they arose from the milk of a cow who was affected with the disease. Now, it was a very serious thing indeed for it to go forth to the public that well-water was a good and sufficient supply, unless the wells were made in such a way as to cut off all surface water. With regard to rain-water, you knew the limit to which it could be charged with foreign matters, because the analyses made by Dr. Angus Smith of rain-water in Liverpool, Manchester, and London, showed the extreme limits to which such water could be injured; and how any one could suppose the matters brought down with rain, which could be filtered off very easily, could be likely to be more injurious or objectionable than surface water finding its way into wells, was astonishing. He felt strongly on this matter, and did not like such a thing to go forth unchallenged.

Mr. A. H. Brown, M.P., said he knew there were many difficulties in connection with his scheme, but he should like to answer Mr. Cresswell on two points. The first objection, with regard to sanitary areas, would be found dealt with in his paper. Again, the last speaker had asked how it was possible to carry out the scheme he suggested. He had stated shortly how he thought it could be done, and the principle was already contained in an Act of Parliament, one clause of which was quoted in the paper. He believed it only wanted a little careful working to settle what would be the area of benefit for drainage. With regard to water, it was quite simple, because you only had to make the consumers pay for the water.

Mr. Chadwick said there were tables prepared by the Local Government Board for the distribution of charges over any number of years up to 60, showing how the distribution of charge could be settled equitably.

Dr. Wilson wished to confirm what had been said by Mr. Wheeler. A few years ago he was medical officer of a district near where Mr. Wheeler resided. He had analysed the water from a large number of surface wells, and he could only say he was never satisfied with the condition of any one of them. Then there came a question where the poor people of the Fen country could get their water supply from, because there were only these wells, next the navigable rivers, into which all the sewage of the district went, and, thirdly, the rainfall. In some of those districts, during the dry summer months, you found people paying 2d. for two gallons of water, which was a very serious thing for a poor man with a family; and, therefore, for the sake of both health and economy, it became a question how this difficulty was to be met. After seeing Mr. Wheeler's paper on the available area of every house to provide sufficient water by the rainfall, the difficulty seemed almost to have vanished. He had analysed the rainfall under different conditions, and, after passing it through what might be called a very rough filter, he found it was much purer than any other; and, in fact, it was a good, wholesome water, which he could recommend. He further tested its use it in his own house, the supply for which previously was so bad, that Professor Wanklyn's report of it was that it was a not very dilute sewage. His medical experience of that district would no doubt be borne out by others, that not only were there many organic impurities, but a large amount of mineral matter in subsoil wells which caused a great deal of disease. After a time, he was fortunate enough to convince some landlords and farmers, and induce them to make this change for themselves, and he was happy to say that the practice was spreading. It was a very necessary matter to discuss the larger question of how England was to be supplied with good water, but when you came to look at these districts in the eastern counties, which were very far from that line of water supposed to be brought from the lakes, it was another question, because the least possible expenditure necessary for bringing them within the range of that water supply would be so great, that it would for ever shut them out from any such benefit. They must, therefore, look to the rainfall collected from the houses, and also, as he had suggested, that from the churches, chapels, and schools, might be made available to store water during the winter, which would to a large extent supply, during the summer, any deficiency from the imperfect arrangement of houses. At a very small expense, each cottager might provide a rough filter, which would render the rain-water far superior to that usually obtained in the Fen land districts.

The Conference then adjourned for luncheon.

On re-assembling, **Mr. Stansfeld, M.P.**, took the chair

Dr. Yeld said it struck him, when Mr. Brown was reading his paper, that the Act of Parliament he had recently introduced into the House of Commons was based on that paper, or that the paper was based on the Act. It was called the Public Health Improvement Act, and was a small Bill. They all knew that Mr. Brown was very happy in passing small Bills through Parliament, but in considering the rating question, the latter portion of the Bill was well worth the consideration of all urban sanitary authorities. He quite agreed that in rural districts some injustice might be done in rating properties which were a long distance from the village, and making them bear the burden of the water supply and drainage of the village, but in reference to urban sanitary districts it did not appear so unjust. In that Bill Mr.

Brown had a provision that for such purposes, in urban districts, a separate sewage rate should be made, but one consequence of that would be to give immense difficulty and trouble. Then there was another thing which was pointed out by Mr. Cresswell. It was a grave question whether in large districts, urban sanitary districts particularly, although a gentleman's mansion might be some little distance from the outskirts of the borough, and although he might not make much use of the drainage area of the districts, still in the matter of health he must be much benefited by the works carried out by the local sanitary authority. He therefore hoped that gentlemen representing urban districts would examine the Bill, and bring it before their local authorities.

Mr. Shute wished to say a word or two on the subject of reservoirs. Mr. Wheeler had spoken of the importance of collecting rain-water for houses, and the same principle might be carried further, as it had been done to a certain extent in the north by making reservoirs, probably because they had better sites for so doing than in the south. These reservoirs had a treble advantage, that they not only supplied pure rain-water to towns and villages, but prevented floods by storage, and were also useful as sources of power, being largely used for that purpose in the North of England. They could be usefully supplied in many rivers by making a dam below the weirs, without damming back the water in any way. Of course, to get a supply of pure water in that way, you must have a deep dam, because a shallow pool would soon get foul. In some places there might be difficulties in getting land, but with collective action they would not be insurmountable. He thought it would be of great importance to London to make reservoirs in the Thames valley.

Mr. W. H. Cutler, C.E., wished to say a few words on the question of rating—more especially with regard to water rating—before it was passed over, as this was a subject of very general interest, and one which it appeared was very little understood. Only a few days ago a large and influential deputation waited on the Home Secretary to bring before him the question of the charges of the London water companies, and objected that the water rates were increased from time to time, but they did not seem to have understood how these rates were levied. When those rates were first arranged, it was doubtless taken into consideration that a fair basis should be the value of house property, and in the Waterworks Clauses Act, and in various private Acts passed from time to time, the water rate was almost invariably based on the value of the premises supplied. He knew the case of a house standing on Castle-hill, Windsor, which, in the reign of Edward III., was worth 13s. a year, but was now worth £150. It would be absurd to say that the house was now to be supplied with water at a rate of 5 per cent. on the annual value of 13s., by which the water company would be very inadequately repaid for the supply. The water rate was based on the value of the premises supplied, because it was about as fair a way to get at the value of it as could be devised. The deputation before Mr. Cross the other day complained that the water rate was increased 50 or 100 per cent. for the same quantity of water, but then that quantity of water had gone up in value. It should also be taken into consideration that the water rate was not raised exactly at the time when money had depreciated in value, and although based on the gross value of the premises, that was almost invariably got at by the rateable value. The way the rates were levied very much depended on how the works were first constructed. If the works which conferred a benefit on a certain district were constructed by a sanitary authority, the necessary capital was borrowed, and had to be paid back in thirty years. It had been contended that it was only those who were actually deriving the benefit who should pay the rate, but that would not be at all a fair way of looking at it. Suppose the case of a sanitary authority supplying a town with water: in a certain street there might be 12 houses on each side; the owner of one side might wish to have his houses supplied with the water, but the man on the other side would not, saying he had already provided his houses with wells. The man who had the water would pay the water rate at the beginning when the capital was being paid back; but at the end of the thirty years the man on the other side might say that he found his wells had failed; he did not get so good a supply as he hoped for, and would have his houses supplied from the water-works; but the other man had already paid for the water works, and this one would only now have to pay for the working expenses and interest on the money, which would be exceedingly unfair.

The Chairman asked what alternative Mr. Cutler would suggest?

Mr. Cutler said a compulsory rate. The money was generally borrowed on a compulsory rate, and he did not think that bore a sufficiently large proportion to the non-compulsory rate. The way to arrive at it would be to consider what part of the rate was devoted to paying back the capital. There was a great outcry now about constant supply, but that subject seemed to be generally begun at the wrong end, because the question was, were the water companies to have powers granted to them of compelling people to put their fittings in a state to receive a constant supply. No doubt it would be a great saving to the London companies if they could grant a constant supply, and if the fittings were properly constructed; but if there were a constant supply over the whole district, there would be immense pressure in the lower parts, and the waste would be enormous. He had taken a good deal of interest in this question, and had under his control some works which had been in operation since 1696. When he took them in hand he had to entirely reconstruct them, and he would undertake to say that they were now as perfect as any in the country. The water was supplied at a low rate very easily, and the supply was enormous; there was an immense amount of waste, but the water was easily and cheaply supplied, and he should be happy to show the works to any gentleman who would like to see them, on any Thursday. The works were situate at Eton, and supplied Windsor, Eton, and Clewer. There was a very low fall, hardly ever exceeding three feet, but that was sufficient to raise the water to the height required, the lower part being supplied by a French undershot waterwheel.

Mr. Chadwick asked if Mr. Cutler was speaking of a supply by a company or by a town?

Mr. Cutler said he was the proprietor of the works, which had been in his family for more than a century.

The Chairman said Mr. Cutler had been dealing with two totally distinct questions, though they were sometimes supposed to be associated, because of the uncertain use of the word "rate." The rate which you paid to a local authority in common with all other ratepayers for a public object, whether you got a sufficient return for the individual payment or not, was a totally different thing from the rate or price you paid to a private company for an article which was supplied. He did not suppose the Conference would care to take up much time with the question of the London water companies, which was a very large subject, and was likely to have the attention of the Legislature ere long. He did not think, whatever Mr. Cutler's views might be (and there was something to be said, no doubt, from his side of the question) as to the justice of increasing the charge for water as the value of money decreased, and the cost of obtaining it increased, that the general argument would satisfy London householders, particularly those who paid large rents, and who were charged upon their rent, or on the annual value of their holding, which was put up at every valua-

tion of the metropolis, and which implied a heavier charge, without consuming more water, and without, as far as he knew, any increased cost in the production of the water for their consumption. It did not seem to have been a sound bargain on the part of the public, but it was a difficult question to deal with, and no doubt would have to be dealt with by the Legislature. With reference to the question of paying for certain sanitary purposes in rural districts, he agreed with Mr. Brown. He had shown, both here and in Parliament, that the absence of some greater elasticity in the statutory arrangements for the imposition of a charge for these sanitary improvements was a check on these improvements, and his paper opened with a category of instances in which real improvements, necessary in rural districts, were prevented by these difficulties. He believed every one in that room was aware that these difficulties did occur. If you had to deal with an urban population, you could deal with it *en masse:* but in dealing with an irregular, scattered, rural population, you wanted more elastic machinery. No one could doubt that the fair thing was that the consumer should pay for the articles produced for his use, but he could not pay in this case like a man who went into the market and bought a thing which was always for sale. A certain amount of capital had to be invested in the creation of water-works, which had to be paid off in a certain number of years, and to pay current expenses. The argument of Mr. Cutler was this, if he followed him aright, that the cost of construction ought not to fall entirely on those who, at the outset required the use of these water-works for their own purposes, and that was true, but without any alteration in the law, that state of things already existed. It would take 30 years to pay off the interest and principal expended in the construction of works, and during the whole of that period, every occupier who came in to use the water, contributed not only to the actual cost, but to the repayment of the principal and interest. If it were said that that might be so, but at the end of 30 years, the whole cost was paid off, and then those persons who originally had wells of their own, might come in and enjoy the use of those water-works without paying anything towards their construction, the practical answer was this, in all human probability long before that further extension would have become necessary. After all, these things were progressive. If the population increased, you had to add to the capital outlay, and in that way, those who did not contribute at first, did so at some later time. He had no objection to the statement of the principle, but he did not think it was an objection to Mr. Brown's scheme; it was a point to be borne in mind in the construction of clauses, so as to secure that no injustice, even in that unlikely case, should be committed.

Dr. Yeld asked if the same principle would apply to the drainage areas referred to by Mr. Brown?

The Chairman said, in his opinion, sanitary statutes required some further elasticity. He was responsible for the original conception of special drainage districts when he passed the Local Government Act, but that method had its disadvantages, because as soon as you constructed a special drainage area it became a rating area for all purposes, and the multiplication of small rating areas was an objection. Then the Act was not sufficiently elastic. In his opinion it was sufficiently so at the time in its principle, that you must not throw the cost of work, which was to benefit the small area, on the whole sanitary area. He wanted to introduce the principle, and he did so in the clause enacting the establishment of these special drainage districts; and he did not carry it farther at the time, for a reason which he had explained before, and which had to do with the methods by which you were compelled to work in framing Acts of Parliament. You had to frame them so as to pass, and you could not exhaust the whole of the subject logically. Practically speaking, you wanted to gain certain ground; you thought the time had come for exhausting a certain branch of the question, and you did so: or that the time had come for making another step further in principle, and you did that. You knew you had sown seed which would spring up and bring forth fruit some time, in the shape of an Amendment Act. That was not necessarily an evidence of incapacity or want of foresight in those who framed Acts of Parliament; sometimes it was an evidence that they knew their business. He was the author of the clause, and as its parent he was perfectly willing to admit its imperfections, and to say that Mr. Brown had drawn public attention to an imperfection which he, for one, was quite willing to see remedied.

The Chairman then invited discussion on the three geological papers of Mr. De Rance, Mr. Lucas, and Professor Prestwich.

Mr. Lucas stated the substance of his paper, "Water-shed Lines: Subterranean Water-ridges."

Mr. Chadwick said, in talking of water-sheds, they were talking of something visible and palpable, the water-shed referring to the whole surface, from the hill top to the valley bottom. As to any other water-sheds, such as had been referred to, that was another thing, and ought to receive another name, because it dealt with something invisible and unknown, and a water-shed in that sense might carry one across the Channel.

Mr. Shelford, C.E., F.G.S., said he was a worker in the field described by Mr. Lucas, but quite independently. Last year, the Metropolitan Board of Works having brought in a Bill for the purpose of supplying water to London from the chalk, it fell to his lot to investigate for them the chalk district to the south and south-east of London, and he desired to bear his testimony to the value of Mr. Lucas's map in that investigation. It was conducted by gauging the springs and streams, by measuring the depths of water in a great number of wells, and by consulting the maps published by Mr. Lucas. The general result shown was that the bed of the chalk dipped towards the Thames, and the subterranean water had a tendency to fall also in that direction. As Mr. Lucas's map showed, there was a great fault which threw up the chalk against the London clay, and so stopped the flow of water in the neighbourhood of Deptford, where the Kent Water-works supply was drawn from, and, further to the west, there was a subterranean anticlinal, which also stopped the water, so that the general trend of the whole water which fell on the chalk to the south and south-east of London, was towards the north, and thence to the east, where it issued into the Thames at or about Gravesend. That fact was further proved by the sections of the River Thames, which showed a certain deepening of the river at that point, which could only be accounted for by the fact that there was a great burst of subterranean water into the river there. Whilst that was the underground condition of things, on the surface it was very different. The River Cray was entirely a chalk river, and the River Darent partly so. There were also other springs, both permanent and temporary, called "bournes," which flowed at different times; and it was quite impossible for anyone, with only a geological map in his hand, to find out what were the water conditions of the district. With the assistance, however, of such a survey as had been carried out with great spirit by Mr. Lucas, there was no doubt that the subterranean water conditions could be much better understood. He also wished to say a word in support of the suggestion made by Captain Galton, that the different authorities who had information at their command should be put into communication with each other. He had lately been to Italy, on an expedition connected with the hydraulics of a great river there, and had access

to the Government Department, and had been much pleased to find how elaborate the information was which they possessed. He had with him specimens of the documents and diagrams that were prepared by the Italian Government, which he should be glad to show anyone interested. They showed not only the water line of the river, but the matter in suspension, the temperature of the water, and of the superincumbent air, the rainfall, the flow of the rivers, and other matters. There was no comparison, however, between Italy and England; first, because the Italian rivers run into tideless seas, and the English into tidal, which everyone acquainted with tidal engineering knew meant an enormous difference. Another thing was, that in Italy there were a large number of military and other Government officers who had little or nothing to do, and they had, therefore, better means of getting information with facility than in England. He would venture to suggest that, as a first step, the information which was required should be formulated, and that some society, like the Society of Arts, should put into shape what actually was required, so as to ask the Government for something definite. Even if they were not successful in the demand, if the formula was a good one, it would be adopted by a great many gradually, and would stand or fall upon its merits.

The Chairman next invited discussion on questions connected with the conservancy of rivers.

Mr. Dillon read a portion of his paper "On the Effects of Under and Arterial Drainage on Rivers and Floods."

Mr. Lloyd said he had had the honour of giving evidence before the Parliamentary Committee, to the effect that the drainage works on the lands of the upper catchment basin contributed to increase floods. It might be a moot point whether under-drainage did or did not increase floods in a river, and it had been said that by under-drainage you got yesterday's rain and to-day's rain. He did not himself feel confident on that point, but he was confident that surface drainage on the upper part of the catchment basin was certain to contribute to the increase of floods. He could point to open mountain sides where, for centuries past, there never had been any gutters or cuts made, but where, within his own memory, there had been open gutters cut down those mountains on purpose to dry them. It was clearly manifest to any one that, if you provided gutters as water-courses along sides of mountains, the tendency must be to vastly increase the flood within those rivers. He did not believe that the measure proposed by the Government would be the unpopular one some thought; but, whether it was or not, he believed it was a just one.

Mr. Rawlinson, C.B., wished to explain some evidence he gave before the committee on river floods, which he found had been misunderstood by a great many. He stated then broadly, and he now reiterated the statement, namely, that drainage and cultivation had nothing to do with increasing the excessive floods which took place in rivers; and he stated further, that no work of man that had been, or ever would be done, in the shape of drainage or cultivation, would in the slightest degree affect excessive floods. The three elements upon which floods depended were entirely beyond the reach of human interference. There was the salt ocean to be evaporated, the heat of the sun to raise the water, and the atmosphere to convey it away, and to precipitate it. When man could control or modify any or all of these elements, he would have power to modify and control excessive floods, because it was of excessive floods that he wished to speak. There were floods and floods. He should be foolish to say that land drainage and cultivation, and arterial drainage did not let down ordinary water-falls more readily than they came off land without drainage, but those waters did not cause excessive floods. They went away, when the river was in moderate flow, peaceably and quietly. A flood was caused in this way. When you had rain on rain, that is water on water, and then, whether you had a surface which had been drained 4ft. or 6ft., and made into the character of a sponge, or the same area as it was before it was drained, in the character of a swamp, when the rain had been continuous, week after week, and the subsoil was saturated up to the surface, and heavy rain continued to fall on that area, whether it was rocky or sandy, or a drained subsoil, it made no difference, as in such excess you got seven-eighths coming down to the river, causing an excessive flood, as such conditions caused it 10,000 years ago; and if the country remained geographically as it was, would cause such area to be flooded 10,000 years hence. There was no fresh water on the surface of the globe, or within the earth's crust, which had not been carried there by the atmosphere. Many persons had, however, a sort of idea that there must be an underground manufactory of water, and they seemed to think that you had only to sink a well deep enough and you would get water. Thousands of pounds had been so wasted in fruitless attempts to get water where it did not exist, because there was no more a general distribution of water in the stratification below the crust of the earth than there was on the surface; and, if he might use a comparison, the subsoil water of the earth might very justly be compared with the surface water; it lay in what may be termed lakes, rivers, ponds, and pools; and as upon the surface the dry area is very much in excess of the wet area, so in the substrata of the earth's crust, the dry or waterless areas are very much in excess of water-bearing areas. Again, there was not one square mile of the earth's crust which had not been fissured, having water-tight faults; if it were not so, mining would be almost impossible. The earth's crust is in all places fissured by faults, one portion of the stratification being lifted above the other: it is also interleaved with impervious strata. There are, of course, water-bearing strata, and because you get water by sinking in one place to a certain depth, it did not follow that you would get it a mile away. Then, with regard to the depth at which water was found, it was supposed even by some intelligent people that you had only to go deep enough and you would get more water. But what was experience? Take the deep coal mines which had been sunk in the north of England. There were mines from 1,800 to 2,400 feet. They generally commenced in the magnesian limestone, and to the extent of 600 feet you might have overwhelming volumes of water, which cost great sums of money to tub out, but after getting down to 900 or 1,000 feet you were free from water. The upper portion of the shafts were what was called "tubbed," that is to say, lined with cast iron plates to keep out the water, but when you got down, say 1,000 feet, you had to tap the casing to carry water down, to water the roads, and keep the place in working order. In going through the oolites and mountain limestone, you often met with hot springs, and there you necessarily had an underground substratrum of water, not necessarily in large volumes, but going down in syphon-like fissures, probably 5,000 or 6,000 feet. Those springs almost always occurred in limestone districts. Some philosophers asserted that volcanic action was due to the emission of the ocean into the volcanic region, but he did not believe it. He did not believe that, excepting accidentally, where a volcano might spring out of the depth of the ocean, and the surface might come in contact with the sea, or where it might be immediately on the edge of the sea, and might rupture the earth's crust, that the two were at all connected; as the deep-seated action of a volcano was beyond the reach of any water from the surface of the earth. With regard to river conservancies, it was very important that their areas should be defined, and that the volume of water falling and flowing off should be ascertained, but there were things which must be known beyond these. To

guage a river, and to ascertain the area, did not always give all you required to know, whether you would be safe or not in adopting the area for water supply, if those facts had only been collected over a brief period. It would take a century before you could get all the reliable facts that such an area would give you. The rain guage might also be excessively delusive to the engineer. Water was collected in a rain guage, which was a vitreous substance supposed to store all that fell upon it, but in the valley of the Thames, for instance, where the average was 30 inches, he found this law to prevail, and not only here, but wherever he had studied the rain guage tables. Take the average over a series of years, and add one-third, it would give you the maximum, and if you deducted one-third it would give you the minimum, and the dry period over the flooded or wet period would be about as one to two. But that estimate might also be most fallacious, because it depended how the rain fell. He had known on the east coast twenty months continuously, when no water could be collected from that surface into a reservoir made to receive it, and in the height of summer in South Wales, if 2½ inches, which was a very heavy fall, came down in a week you would have nothing from the gathering ground there. It might go on for the entire summer, a heavy fall for a week, and then two or three weeks of dry weather; and, therefore, the minimum fall would be reduced again to an item you had uot at all anticipated.

Mr. Chadwick asked Mr. Rawlinson how many instances there were in his experience, of success in deep borings to something like a thousand feet, for supplying water to towns?

Mr. Rawlinson said he knew very few. There was the Grenelle well, near Paris, which went down about 1,800 feet, and brought water up at a temperature of about 81°. In all these instances, where you went to a great depth in the earth's crust, the water which filtered from the surface, and got down there, came in contact with all the minerals between the surface and the bed in which it lay, and brought some of the salts of those minerals with it to the surface. You might sink a thousand feet, and get water absolutely worthless, as at Rugby, for instance, where they sank a thousaud feet and got none; they borrowed £5,000 more to go further, went 1,200 feet, and got brine.

Mr. Homersham said he knew enormous areas of land covered with clay, having a subsoil of chalk, where what were called "dumb wells," had been sunk through the clay into the chalk, and the drainage of the land had been carried into these "dumb wells," and was all absorbed by the chalk beneath. That was still carried on to a large extent in some districts, and he had found three generations of men who had been engaged in this occupation. In that case, no doubt the effect of drainage was not to increase floods, because none of this water would be delivered into the river; it went into the chalk at an elevation varying from 500 to 600 feet above the sea; it went down into and along the great body of the chalk through fissures until it was discharged into the ocean by subterraueau drainage. In this case, surface drainage, instead of having tended to make floods in the river, had rather tended to diminish them. There were other localities where drains would increase the flood, because the surface water would reach the rivers more quickly. With regard to the point mentioned by Mr. Rawlinson, that you did not get water below a certain depth, that all depended on the strata you were sinking in. He was old enough to remember when there was a great contest at Liverpool, whether the town should be supplied from the red sandstone or from surface water. After a great deal of contention, it was made to appear that it was not possible to get water from the red sandstone to a greater amount than one million gallons a day from only one well; but, not more than two or three years after that, three million gallons from one well only was got without any difficulty, and at the present time some enterprising contractors in Liverpool had sunk a well to a depth of something like 1,400 feet or 1,500 feet, and had got an enormous supply. At present he could not state the exact amount, because the engines and pumps were not got to work.

Mr. Chadwick asked what was the quality?

Mr. Homersham said very good; not more than 14 grains of solid matter per gallon. Much of the water in the red sandstone was of very good quality, and if it were rather hard, it could be softened by Clark's process, and delivered far superior to anything we had in London. Around London there were something like 4,000 square miles of chalk not covered by clay, where all the rain was absorbed as it fell. He could show them 100 square milcs of country in one patch where every drop of rain was absorbed as fast as it fell, and never appeared at the surface. It was in circumstances like these, where you had a large area of absorbing country, that you succeeded in getting enormous volumes of subterranean water, and when you did get it, it was worth all the trouble and expense, because as a rule it was wholesome; neither hot in summer nor cold in winter, and did not freeze in the pipes. With regard to surface water, whether it was from Loch Katrine or from rivers, you always found it contaminated with a large amount of living organic matter. No doubt it was sometimes soft, and contained very little mineral matter in solution, but against that must be put the fact that the bottoms of lakes were covered with mud, and all kinds of organic impurities which were taken in solution, the effect being to nourish animalculæ in the water, and the consequence was that although you had it soft, it was not nearly as wholesome as that obtained in the chalk. London was very admirably situated in this respect, and there was not the slightest difficulty in supplying the whole of London with water from subterranean sources. Twenty-five years ago, he sunk a well and made works to supply Charlton and Woolwich; it was then said that you would have water for a short time, and then it would cease, but at the present time, in these the only districts near London where there had been competition in the supply of water for the last 50 years, the Kent Water Company derive all their supply from chalk wells. Ten million gallons were supplied, including Greenwich and Blackheath, and a much larger quantity could be got without difficulty.

Mr. Rawlinson said he was quite sure that Mr. Homersham did not mean to say that all the rain falling on the surface was absorbed, whether on the chalk or anywhere else. The rainfall in the Thames valley had been accurately gauged, as also in the valley of the Lea, and taking the average rainfall of one at 27 inches, and the other at 25 inches, the volume that flowed out of the Thames did not exceed six inches. One-third of it might go in flood, and one-third in perennial springs, but 20 inches absolutely passed back into the atmosphere, re-evaporated, and never appeared in any shape. Again, with regard to the chalk absorbing wells, which Mr. Homersham had mentioned, no doubt that action was taking place artificially as it had been from time immemorial naturally. There were large sand and gravel pockets or pipes in all chalk formations, filled with gravel, like inverted sugar cones, the origin of which was this. The rain-water had fallen on the surface, and pure water being a powerful solvent of lime, it combined with the lime, dissolved it and filtered down, and was carried away in springs. That went on, and the gravel followed it down, and so you had these inverted cone and pipe deposits iu the chalk in some instances to great depths, simply shewing the solvent action of the water on the lime.

Mr. Homersham, in explanation, wished to say that he certainly did not mean that all the water which fell

was absorbed, because a certain portion went to support vegetation, but none ran off the surface; although the Thames only gave six inches out of 26 inches which fell on the surface, a very large proportion, nearly two-thirds of it was absorbed. It did not evaporate away into the atmosphere as Mr. Rawlinson asserted, for it was by means of artesian wells sunk into the chalk in proper situations that you might get at this water so absorbed.

Mr. Baldwin Latham said he believed he was the only person who had made any series of experiments on the actual amount of water yielded by the chalk formation. He could not now give the exact results, but his guagings, which had been carried on daily during the last four years, on areas in the chalk formation exceeding 90 square miles, showed conclusively that what Mr. Rawlinson had stated was an absolute fact—that the amount of water yielded by the chalk formation depended not so much upon the total amount of rain which fell annually, but on the amount of rain which fell at particular periods of the year. Since the 7th of March this year, the wells throughout the whole of the water-shed of the Wandle and the Hogsmills rivers had absolutely been declining, although we had had a certain amount of rain in the interval. It was impossible for any amount of rain which would fall between now and next November to alter the condition of those wells, which would be one of continual fall. Mr. Lucas' paper, and the diagram that he had exhibited, showed conclusively the value of these hydro-geological observations. It was quite impossible to know whether water was going to be good or abundant in quantity, unless you had this class of survey undertaken. If a man put a well on the top of a hill, with the water flowing both ways from him, he was exactly in the same position as one who was collecting water at the ridge of his house rather than at the eaves; yet such things had been done. Not many miles from London, a waterworks had been established on the very top of the North Downs, and what had been the result? The company had been in such difficulties, that they had never been able, except by borrowing water from other people in the neighbourhood, to supply their district. The quality of water was of equal importance to its volume, and it was quite clear that if you had a town population living in a particular drainage area which had to supply the wells, you might tell what the result of the use of that water supply would be on the health of the population using it, He knew a town very well which drew its water supply out of the chalk, and there was a population of something like 40,000 persons living in the drainage area, which did not much exceed 20 square miles. That town was never free from typhoid fever; but the fever never came except at particular periods, when you got a minimum period of flow. It was a farce to suppose that the springs were flowing with uniform quantity throughout the year. As a general rule, the springs in the chalk were at their highest in the early part of the year, although sometimes they were as late as May or June; but, as a rule, they were always lowest about November. The difference between the maximum quantity flowing off, and the quantity of minimum period, was very great. As a rule, when a large quantity of water was given to the springs, a large quantity flowed away; so that at the minimum periods the difference in different years was not so great. There was likely to be a greater scarcity of water in the chalk at the end of this year than at any time during the last four years, simply from the distribution of the rainfall. One of the most remarkable circumstances with regard to the rainfall, and the yield of springs was this. If there was a good rainfall in the month of December, the springs were sure to be high afterwards; but if you had a short supply in that month, it fixed the character of the springs during the ensuing year. With regard to water from the red sandstone, he understood that the Corporation of Liverpool had abandoned the deep well for procuring additional water supply, because the deep boring, carried to a depth of 1,300 feet, was shown to yield no more water than the shallow borings, and they declined to go to any further expense.

Mr. Homersham said that this was a misapprehension.

Mr. Latham said if he were wrong, he might be corrected, but that was the impression he got when he visited the works. If it could be shown that these wells did yield such a large quantity of water, it must be remembered that the sewers of Liverpool were made in the same rock from which they took their water supply; and he had heard that in order to make the sewers as cheap as possible, it used to be the fashion, as described in the "Transactions of the Civil Engineers," to hew out a tunnel in the rock, and put an arch over it to prevent the materials above falling in. Was it suprising, then, that there was no town in England which could compare with Liverpool with regard to its fever or cholera rate, when it drew a large portion of its water supply under such conditions. He quite agreed with every word said by Dr. Tripe in the morning, on the question of drawing water from wells being so exceedingly dangerous. He said you must make the upper part impervious, but experience had now shown that if the whole of the materials were of a porous character, or a porous geological character, no works could be carried out which would shut out the water. That was shown by a case which was well known to Mr. Evans, in which his partner brought an action against the Grand Junction Canal. It was further shown at Croydon, where they lined the wells with iron cylinders, and yet the pumping of the wells affected the sewers. When the ground was perfectly porous from top to bottom, water could not be shut out of a well. Surface water could only be shut out when there was an impervious strata overlying the water-bearing strata. In the generality of cases that was not so. Moreover, water itself was always on the move, and it might come from a contaminated source, and then it was necessary to trace where the water came from. It was quite possible to know which way the water was moving, so that you could get both the quantity and the quality, which it was so desirable every town should have.

Mr. G. J. Symons having stated the substance of the paper written by Mr. John Smyth, said he wished to make one remark on Mr. Rawlinson's statement, that the quantity of water to be obtained at different depths would decrease in proportion to the depth you went down. It so happened that he was a member of the Committee of the British Association charged with determining the rate of increase of temperature underground, and that committee were about to make an experiment in one of the deepest coal mines (2,445 feet deep) alluded to as being so extremely dry. Everything was in the proper train. The engineer had agreed to allow the experiments, and they were going to bore down from the bottom of the pit, but unfortunately at a neighbouring mine, in the same stratum, at a depth of 1,700 to 1,800 feet, there was such an irruption of water, that the engineer of the mine in which they were going to experiment took fright, and declined to allow a single foot to be bored. Had Mr. Rawlinson not left the room, he should have asked him to give the actual details of the case to which he had referred, where a reservoir had been made, and during twenty months no water flowed into it, because he should like to know where it was, and when it was.

The Chairman said Mr. Brown had left a resolution which he desired to be put to the meeting, which was as follows:—"The incidence of rating for sanitary purposes in rural districts should be reconsidered; rates for sanitary purposes, including water supply, should, as far as practicable, be made to fall on those who are benefited by the improvements." The words, "as far

as practicable," he had inserted, because it appeared to him that without those words the resolution was too binding and absolute, but with those words it seemed to indicate a want of elasticity in the present arrangements, which might be remedied. He would move that resolution.

Mr. Cresswell seconded the resolution.

Mr. Lloyd asked if that applied to all sanitary measures, for instance, to the prevention of floods in river valleys? The Legislature had laid down that lands not affected should pay because they contributed to the harm done.

Dr. Tripe asked, in carrying out the Nuisances Removal Act, who would be the persons benefited; those where the nuisance was removed from, or other persons?

The Chairman said, as far as he knew Mr. Brown's views, he did not think they went beyond sewage and water supply.

Mr. Cresswell thought the objection was very well timed, because the resolution might imply even the removal of nuisances; but the words, "in rural districts," were intended to confine the alteration, in the incidence of rating, to rural sanitary districts for sanitary purposes, such as water supply and the disposal of sewage.

The Chairman suggested the following words should be substituted: "The incidence of rating for sanitary purposes in rural districts should be reconsidered. The rates for such sanitary purposes as water supply and sewage, should, as far as practicable, be made to fall on those who benefited by the improvement."

Mr. Alcock said he was not prepared to accept a resolution of that kind, which was an abstract resolution, and which might mean a great deal or nothing at all, according as it might be carried out in detail. If any alteration were to be made in the way suggested by the Bill of Mr. Brown, he thought it would be found almost impracticable on the part of rural sanitary authorities to carry out any improvement, so far as the sewerage and drainage of their districts was concerned. Mr. Brown had put into clauses what he proposed, and those who had seen his Bill might assume that they were pretty well acquainted with his views of the question. He was sorry he was not able to be present when Mr. Brown spoke in the morning; but, as he understood his Bill, it was proposed that, in case of a sanitary authority carrying out works of sewerage, they must levy a separate rate for the sewer, and that applied not only to rural, but also to urban districts, the rate being confined to houses exclusively, and assessable on those only within a certain distance of the drain or sewer. The words the Chairman proposed to insert, "so far as practicable," would over-ride the whole, for he thought the clause was simply impracticable. It was difficult to say within what area or what district the sewer did really confer a benefit. He should maintain that a sewer benefited the entire district, even although a particular householder might think proper to carry out his system of drainage on some principle of his own, and decline to make use of the sewer. Mr. Brown proposed that he should only contribute provided he was within a certain number of feet of the sewer, but there might be one of the houses within that distance, and another just without; the one within might happen not to use the sewer, and the one without might happen to use it; yet Mr. Brown would make the one within, who did not use, contribute, and the one without, who used the sewer, escape, which clearly would be unfair. All those who might use the sewer were the persons directly benefited. But the whole district was indirectly benefited, and ought to contribute; and unless the meeting were prepared to lay down a rule which would have a great tendency to prevent sanitary measures being carried out, it would hesitate before it agreed to any such resolution. The direction of public opinion, as he understood it, was rather to extend the area of rating, and certainly not to limit it in such a way as was now proposed, and, therefore, he hoped the meeting would not assent to the resolution.

Mr. Latham, having had considerable experience in dealing with rural sanitary authorities, was of opinion that if a resolution of this character were passed, such as would ultimately have the effect of altering the incidence of rating, so that it should be entirely confined to clusters of small houses which might require drainage and water supply; all sanitary improvements in rural districts would be at an end. It was quite impossible for these small clusters of houses, inhabited, as a rule, by a class of workmen who were paid the very lowest wages, to pay the cost of such improvements, either through the owners or by the men themselves. Then came the question how came the men to congregate in these clusters and villages? Simply because the agriculturists did not house them on their own farms. If they were all kept upon the soil which they tilled there would be no aggregation in these villages, and nothing like the difficulties, in a sanitary point of view, which now occurred. Men had often to walk three or four miles to their work, and the village was sometimes in the same parish and sometimes not. If the village alone had to bear the expense of sanitary work, the great agricultural district which reaped the benefit of the labour of these men, who lived in these unsanitary villages, would go scot free, whilst the men would still further degenerate and get in a worse state. Seeing that the land only contributed one-fourth of the cost, which appeared to him to be a very fair arrangement, and which, if anything, ought to be increased, and looking at the great benefit it was to the agriculturist to keep his own men in health, just the same as it was to keep his horses or stock in health, he ought to contribute to the cost of these sanitary works. He was well acquainted with the number of the districts where this agricultural element was always cropping out. It was the interest of the farmers, as a rule, to prevent works being carried out, in order to save their own pockets, and almost universally the agricultural element was averse to the expenditure of money in villages for sanitary purposes, and, consequently, very little of such work was done. It was very often in these villages that fever broke out, and was carried into the towns in the milk and other produce, and, therefore, they should be extremely careful before they passed a resolution of this kind.

Mr. Wheeler having had something to do with rural districts, considered that sewering the district was a direct benefit to the whole parish, because if you had typhus or other similar diseases, it meant an increase of the poor rate, the payment of which must fall on the whole of the parish. Where a number of cottages were crowded together, the ordinary plan was that all the drainage should run into an open ditch, and every inhabitant of the parish who passed through the village suffered from the stink; therefore, the sewering of the village was, in this respect also, a direct benefit to the whole of the parish, and the expense should be borne by it. Still some distinction might be made. If he remembered rightly, in the case of Birmingham, an attempt was made to charge the cost of sewering in some way according to the benefit received, and every house which drained into a sewer had a water-closet that paid a special rate beyond the ordinary amount. There might be one general rate for construction, and an additional rate for those who had water-closets. A distinction should be drawn between water supply and sewerage. A general system of sewerage was absolutely necessary, but water supply could be provided in rural districts by each house separately from the others by collecting the rainfall, as he had endeavoured to show in the paper he had contributed.

The Chairman said there was a great deal in the remarks made by the last three speakers with which he entirely agreed, but he had a case in his mind which it required some modification of the law to meet. For instance, suppose there was a speculative builder running up a lot of houses in a particular place where he could not get a water supply, and could not drain them for himself, the local authority ought either to have the power of forbidding the houses being inhabited, or to meet the builder by bringing the sewage-works or water supply sufficiently near, and the man who erected those houses was bound to make some fair contribution towards the expense. He did not think the whole parish was bound to bring water, and take means to provide sewerage, for anyone who chose to build a row of houses in the most unlikely place for houses to be built.

Mr. Chadwick said it was sometimes very convenient to levy a very heavy charge, but to relieve the owners and occupiers by spreading it over a wide area, or over a period of years, and this was practicable in a village as well as in a town. For example, you might have drainage of cottages costing £5 each, and when you came to distribute the charge, instead of levying the rate within two or three years, if you spread it over a longer period, the rate would not come to more than 3d. or 4d. per week. There was no doubt that system was applicable, and tables were devised for the purpose by the Home Government Board. That, in his view, would meet the difficulty of adapting the charge to the benefit received.

Mr. Eldred said there might be difficulties with respect to the drainage of a district being included in one local authority. Suppose there were three local authorities, and the one at the outlet of the drainage had done nothing, the centre one had carried out a scheme passed by the Local Government Board, and expended a large sum of money on it. They would have means sufficient for their own property, but by carrying out a system of sewage for the whole district, they would not have enough, and would have to be reconstructed at a considerable expense. He did not think it would be fair in that case to levy the additional rate over the whole district.

Dr. Tripe thought there was a great difficulty in uniting together in one resolution two things entirely incompatible. Drainage was for carrying off water, but water supply was for the bringing of water to the houses. Sewers undoubtedly benefit not merely the place where they are laid, but the whole district, directly or indirectly. The water supply benefits chiefly the parties supplied, and scarcely at all those who do not have the use of it. On sanitary grounds it would be exceedingly dangerous to say that only the persons who were immediately benefited should pay, as it would prevent people draining into the sewer, and induce them to have cesspools wherever they could, and thus injure the neighbourhood, and diminish the general health of the district. It was said they would not be allowed to use cesspools, but in order to bring persons within the provisions of the Act, the houses must be within a certain distance. There were plenty of people now outside the distance who would be only too glad to go to the expense of forming a connection with the drain if they had to pay the rate, but if they were outside the distance, and would therefore escape the rate, they would have cesspools domed over at the top, and open at the bottom, carried into the gravel or other subsoil, which would be their sewer. If a resolution were passed something in this form he should not object to it. "That the water-rate should not fall upon the parties which inhabit the district *pro rata*, but that those who use should pay; and that the expenses originally incurred for water works, or a certain proportion of them, should be in the form of a rate." If something of that sort were done, so that those who had the water paid for it, but a proportion was levied by a rate, it would form some inducement to water companies, or to a sanitary authority to carry out this improvement.

Mr. Cresswell said it was very curious that the difficulties which had been so ably urged were raised by himself that morning. The only difference between his statement of the case and that now heard, was that they were put more forcibly and fully. There could be no doubt that these objections were such, having regard to the sources whence they came, as to demand great consideration, and he was prepared to admit that any resolution coming from that Conference had a weight which should make those who moved and seconded it exceedingly cautious before asking other persons to accede to their views. The experience he had gained over many years in the practical working of sanitation had convinced him that they had overcome all scientific obstacles; that engineers, chemists, analysts, and geologists had supplied them with information, and approved the means whereby, if they had the opportunity, they could remedy the evils which beset the people, but the difficulty they now had to encounter was a moral difficulty—to overcome the inaction of the people, and induce them to bear the expense of the improvement necessary for their welfare. When so eminent an authority as Mr. Brown came forward with a well-considered paper endeavouring to remove an obstacle, the force of which seemed to be appreciated, he conferred on all sanitary reformers a great obligation, and he (the speaker) had ventured to bring the matter before the Conference, so that it might be discussed. He could not help thinking that they had somewhat misunderstood the object of Mr. Brown's measure. He gathered from the remarks made that there was no objection to the proposal, so far as regarded the incidence of the water rate, but as to the question of sewage disposal and sanitary work, it had been urged with great power that everybody, whatever his position might be in a parish, whether a territorial magnate or a humble cottager, was interested in the sanitary improvement of the district, and in the purification of the rivers. He admitted it, and he did not think there would be any reason for exempting anyone from bearing a fair share of that burden. There was the limit in the Act of Parliament, of one-fourth for the agricultural rating, but there were many other cases. The incidence of rating described was not the incidence on the individual only, but on a place or part of a district. The Chairman had called attention many times to a re-arrangement of sanitary areas, and if that measure had been carried, a great deal of work, which Mr. Brown was endeavouring to achieve by this Bill, would have been accomplished. What was wanted was not to lay down an arbitrary law and say that within a certain distance of the sewers people should pay, and at another distance they should not, but to give power to some local authority—County Boards, for instance—to define the area within which the benefits of every sanitary improvement were received, and within which the contributions should be made to defray the expenses. He wanted to see such a state of things as this altered—in one corner of a parish there may be an industrious and prosperous community manufacturing a considerable amount of nuisance, in another part of a parish an outlying district contributing nothing whatever to this nuisance, and yet called upon to contribute towards the expense of removing it. Surely it was a matter of justice that there should be a power, vested by Act of Parliament, in some central authority, to relieve that particular part of the parish of the burden of contributing to the removal of the evil, for which it was in no way responsible. In that respect Mr. Brown's Bill would be found to be a great advantage. In reply to Mr. Alcock's observations, he would call attention to Mr. Brown's paper, where he showed that, within a certain distance, all residents were obliged to use the

drains, and it was in the power of the Local Government Board to compel them to do so. If a man was 200 feet away he was not compellable, and he very much doubted whether that should not be extended to 200 yards. But it met Mr. Alcock's objection to say that, according to Mr. Brown's Bill, those only would have to pay who were within the distance, and actually drained into the sewer to be constructed. He thought there was a great deal in the argument as to the direct or indirect, benefit conferred on everybody in the district by a work of sanitary reform, and he should be quite agreeable, if the chairman agreed with him, to modify the terms of the resolution in that respect. But Mr. Brown not being present, he had felt it his duty to defend his proposition, and certainly thought, with regard to the water rate, that some alteration in the incidence of taxation was desirable.

Dr. Yeld thought, by passing the resolution, they would be practically affirming the principle of Mr. Brown's Bill, and before they were called upon to do that, he thought they ought to have an opportunity of carefully going through the Bill, and considering the whole of the clauses. As he said before, it not only bore on rural but urban sanitary authorities, and although this resolution only applied to rural authorities, still there was no doubt an argument might be raised, that if it were good for rural sanitary authorities it was equally good with regard to urban sanitary authorities. The nature of the Bill, which related to the incidence of taxation, laid it down that a separate sewer rate should be levied, and if it went beyond 1s. 6d. in the £, any excess should be levied on the general district rate. It was very questionable whether the clause was workable, and he suggested that it would be better to confine the resolution to water supply only.

Mr. James Lemon hoped the resolution would be withdrawn as far as regarded sewerage, for if it were adopted and carried out, he thought there would be very few drainage schemes carried out at all. Everyone had an interest in the health of a town. If the rate were to be levied on the small area directly benefited, it would be so heavy in many cases that they would not have any rural authority able to carry out the scheme. Only within a few weeks ago, he know of a case where pressure had been put upon the Local Government Board to cut out a certain portion of a district, proposed to be drained, on the ground that they did not want it, and could do without it, because they had cesspools in the chalk. No doubt they could do without it, but it was a very bad precedent if they were allowed to escape from the fair charges they ought to bear. If the resolution passed it would be the most retrograde step the Congress had ever made.

Mr. Chadwick said a statement as to the distribution of the charges that were said to be so frightful on the people, would be found in his paper showing that 3½d. per week, or one halfpenny per day, would suffice for sanitary improvements.

Mr. Rogers Field, as an engineer who had had considerable experience, especially in connection with drainage areas, wished to fully support what Mr. Latham and Mr. Lemon had said. People would object to drainage, and would continue to use cesspools, if by so doing they could avoid a rate. It would be a decidedly retrograde step if such a resolution were passed.

The Chairman said he had arrived at the conclusion that the best course would be to withdraw the resolution. He was under the impression that the matter had been fully discussed on Mr. Brown's paper, and that the resolution which he left behind was intended to be the record of general approval. For that reason he moved it, and Mr. Cresswell seconded it. He was not prepared to say that there was not a case for some modification of tho law, because he thought they had not arrived at the ultimatum in arrangements for the creation of a special drainage area. It seemed to him that Mr. Brown had hit an imperfection, and, so far as he had followed his Bill, the means he suggested were of the right kind. Still there was great weight to be attached to the arguments advanced by several gentlemen well entitled to speak, particularly the objection to giving general approval to a Bill of this kind, on which the clauses had not been discussed *seriatim*. There was also great weight in the view that the function of the Conference was not so much to differentiate between special proposals, as to lay down particular principles, and, above all, to keep before the public constantly the idea of private sacrifice for the sake of public health. In his opinion, those arguments were quite conclusive against a resolution so vaguely drawn as that was, in the absence of that complete understanding which he had assumed to have been arrived at previously. He had sketched out something which more nearly expressed his own views, which he would not propose for adoption, but would read, to show what was in his mind. His view was, that where, in a rural district, either a landowner or a speculative builder erected houses where there was no water or sewage, the local authority ought to make the houses healthy, and his point of view was to increase the power of the local authority, and by no means to increase the exemption. What he had drawn out was as follows:—"That the incidence of rating for sanitary purposes in rural districts requires reconsideration, and that legislative provision should be made enabling local authorities to charge a greater proportion than is now charged of the cost of new sewage and water supply works, erected especially for the benefit of a limited number of dwellings, and necessary for their healthy occupation, on the owners and occupiers thereof." He thought the best course would be to withdraw Mr. Brown's resolution, but in so doing he wished it to be understood that did not imply an expression of any opinion unfavourable to the views Mr. Brown had propounded in the morning.

Dr. Tripe said he should have been happy to propose the resolution read by the Chairman, which only referred to water supply; but he most distinctly spoke against Mr. Brown's resolution in his presence in the morning, and he was quite sure the majority of the meeting held opinions similar, to a great extent, to those entertained by Mr. Latham, Mr. Field, and himself.

Mr. North thought the resolution was very properly withdrawn, and that it had betterrest as it was, without any expressiou of opinion.

The Chairman said that was his view. He was only anxious that, as a consequence of this discussion, it should not go forth as an unfavourable conclusion with respect to Mr. Brown's paper.

Mr. Latham said his view was that it would be extremely dangerous to pass any resolution which would seem to be of a retrograde sanitary character. He did not know what the provisions of the Bill were, but he presumed the resolution was really in agreement with what he proposed in his Bill. Individually, he felt that if a resolution of that kind were adopted, it would do harm rather than good.

Lord Alfred Churchill moved the following resolution:—"That this Conference wishes to express its entire satisfaction at the action taken by H.R.H. the Prince of Wales, President of the Society, in applying to the Government for the appointment of a Royal Commission to inquire into the subject of a national water supply, and it earnestly hopes the Government will take steps without delay to carry into effect the resolution passed at last year's Conference."

Captain Douglas Galton seconded the resolution, which was carried unanimously.

The Conference then adjourned till the following morning.

Mr. J. Clarke Hawkshaw was unable to attend the Conference, but wrote as follows:—I do not think that my paper on "River Conservancy" calls for any further remarks on my part. I may, however, state that Rhineland, of which I have described the drainage administration, is a good representation of other drainage districts in Holland. If I had been able to be present to-day, I should have wished to make some observations on one point in the River Conservancy Bill, and as I think it an important point, I will give my observations on it as briefly as possible. Three descriptions of land are defined in the Bill, flood-lands, intermediate lands, and uplands. Flood lands are defined as lands "liable to floods;" I think they ought to be described as lands lying below the flood level. With the definition as it stands, endless disputes will arise as to what lands are liable to floods, as to whether lands that were liable to floods, but are not so now, should be called flood lands, &c. With the definition I suggest, a line can be put on the survey of the district, marking the flood level, and all lands within it will be flood lands. There is no difficulty in doing this; it has been done for some districts, and it settles the matter once for all. Intermediate lands are defined as lands "draining by subsoil drainage." I thinks the words "subsoil drainage" ought not to appear in the Bill at all, not because I agree with those who say the water flows faster and more copiously off undrained clay lands than off subsoil drained clay lands; on the contrary, I think that much of the water that falls on undrained clay land never flows off at all. It stands in holes and hollows, and is absorbed by the clay in a great measure, and finally leaves the land by evaporation. At a meeting of this Society, in 1855, Mr. Bailey Denton said that deep drains generally begin to run before shallow drains, that they invariably run as soon, and more copiously than shallow drains, and that they continue to run long after shallow drains have ceased to run. I object to the words, because I think they admit a wrong principle of taxation. The rivers of a district form the common channels by which all the water flowing from all the land is conveyed away; and, therefore, all the land ought to be taxed, to ensure the water passing away in those channels without causing loss by floods, or by danger of floods to the lands on the river banks, and the tax for this purpose should be at the same rate for all lands. But as some lands will immediately benefit by the works, that must be carried out to ensure this immunity from floods, they should be taxed at a higher rate. If you once begin to tax lands at an increased rate, because they do something to get rid of their water more rapidly and effectually, why should you stop at subsoil drained lands. If a ditch is dug, if a watercourse is straightened, it has the same effect as subsoil drainage. There is a class of lands which might properly be called intermediate lands, and be taxed at a different rate to the other classes, I refer to land lying not much above the flood level. It can be defined by a contour line on the survey of a district, in the same manner as the flood lands; this has been done for some districts. On the Thames valley drainage plans such a line is shown, 5 feet above the flood line; on some of the plans of districts in Lincolnshire, a line is shown 2 feet above the flood line. The lands lying between such a line and the margin of the flood lands, might properly be described as intermediate lands, all higher lands would be uplands. If the River Conservancy Bill passes the House of Commons, I hope it will not be without some alteration having been made in the definitions of the different kinds of lands. I am sure they will give rise to difficulties and delay as they at present stand.

The Papers will be printed in subsequent numbers of the *Journal*. The report of the second day's proceedings will be printod in next week's *Journal*.

INDIAN SECTION.

Friday, May 23rd; Sir William L. Merewether, C.B., K.C.S.I., in the chair.

The paper read was:—

KURRACHEE HARBOUR WORKS.

By W. H. Price, M. Inst. C.E.

Kurrachee, the natural seaport of Sind and the Punjab, of Afghanistan, and, beyond it, of the rest of Central Asia, although the youngest, is, in combination of political, military, and commercial importance, not the least of those ports of Hindostan which can, at all seasons of the year, shelter vessels of largo tonnage.

Such harbours in India are few and far between, for, setting aside British Burmah (which, with its river ports, is proportionately better provided), they number barely four,* on a coast line of 3,000 miles, beginning on the west side with Sind, and ending on the east with Bengal.

Such is the existing provision of close harbours on the seaboard of a territory measuring nearly one and a half million of square miles, or rather more than the aggregate area of the numerous states of Europe which would remain after deduction of Russia and Sweden.

Favoured, however, by the regularity of the seasons, much fair weather trade is carried on in open roadsteads, at many points, along the coast of India, though not without inconvenience and occasional danger, as notably at Madras, where great works are now in progress,† giving early promise of an enclosed harbour of moderate extent, at a cost of £585,000.‡

Of the two most important harbours west of Cape Comorin, Kurrachee must concede to Bombay the advantages of far greater natural capacity; of a start of nearly two centuries in commerce; and of a score of years in extensive railway communication; of a more densely populated and richly cultivated interior; and, to crown the list, that of being a seat of government.

On the other hand the younger port claims special advantages, even over magnificent Bombay (*Urbs prima in Indis*) in geographical situation, and in climate and weather, as well as in perfectly landlocked shelter, which last greatly makes up for present want of space, so that Kurrachee might well share the motto of the far off and grander Queenstown, in being *Statio benefida carinis*.

Thus, Kurrachee is the harbour of India nearest to Europe, being, as compared with Bombay, nearer by 200 miles to Aden, and by 400 miles to the head of the Persian Gulf, or, in other words, to the terminus of the projected Euphrates Valley Railway.§

* Kurrachee, Bombay, Carwar (very small shelter), Calcutta.

† Under Mr. Parkes, formerly consulting engineer to the Kurrachee Harbour Works.

‡ For convenient comparison in the amounts mentioned throughout this paper, ten rupees are rated as one pound sterling.

§ To Aden:—From Bombay, 1,640 nautical miles; from Kurrachee, 1,435; difference, 205. To head of Persian Gulf:—From Bombay, 1,499 nautical miles; from Kurrachee, 1,099; difference, 406.

It may be added, that the violence of the S.W. monsoon is much less felt on passages from Kurrachee to Aden than on those from Bombay, on which both wind and sea are heavier than on the more northern route.

Looking inland, and, for example, taking Lahore as a commanding point in reference to the north-west frontier, its distance from Kurrachee by rail is less than that from Bombay by nearly 800 miles; and, as regards other important points the difference is even more marked, Quetta, for instance, being only 574 miles by rail and road from Kurrachee, against 2,296 from Bombay, a difference of 1,722 miles.

The recent fortnightly mail experiment from Aden, though unfavourably arranged, has well shown the advantages of the Kurrachee route, by three days earlier delivery of the mails to the Punjab.

It is true that the State Railway line, now in in progress between Ahmedabad and Ajmere, will shorten the distances from Bombay as above given, by nearly 300 miles, but as this junction line will be, partly at least, on the metre gauge, the breaks, as compared with the uniform gauge of the Indus Valley Railway, will go far to neutralise the reduction of distance. With such advantages of distance, and when the lately opened Indus Valley Railway (as yet broken by the Indus, unbridged at Sukkur) shall have attained homogeneous working, it may be expected that Kurrachee will regain its fair share of traffic, in goods and passengers, as well as troops and military stores, which for several years past has—in spite of its geographical advantages—been diverted from it by the earlier development of the railway system in connection with the older ports of Bombay and Calcutta. That under such disadvantages the trade of Kurrachee has, nevertheless, on the whole, continued to increase (having latterly reached a value of more than five millions sterling*) speaks much for the commercial vitality of the place, aided largely by the harbour improvement works, on which, up to the present time, a sum of £490,940 has been expended.

Before particularly describing these works, it will be convenient to give a sketch of the local characteristics and modern history of the harbour.

Kurrachee Harbour is situated on the northern border of the Arabian Sea, its entrance light being in latitude 24° 47′ north, and longitude 66° 58′ east, six miles west of the westernmost angle of the Indus delta, and fifty-one miles west of the "Hujamree," or principal mouth of that river.

Twenty miles to westward of that harbour lies Cape Monze (Ras Muari) terminating a detached spur of the Pubb mountain range, just beyond which the Hubb River meets the sea, and divides Sind from Beloochistan. The nature of its river, soil, and climate have suggested for the Sind the appellation of "Young Egypt," and the analogy extends also to the harbours, for Kurrachee stands in much the same relation to Sind, and to the mouths of the Indus, that Alexandria does to Egypt and the Nile. Both ports, notwithstanding their vicinity to the mouths of silt-laden rivers, maintain a vitality which seems mainly ascribable to the drift being kept off by the action of the prevalent winds, which, in both cases, blow from the port towards the river.

* 58,842,019 Rupees in 1877-78. There is, with occasional variations, a progressive increase on the whole of from:— In 1843, imports, 11,50,925 Rupees; exports, 9,595 Rupees; total, 11,60,520 Rupees; to in 1877-78, imports, 3,02,05,014 Rupees; exports, 2,86,37,005 Rupees; total, 5,88,42,019 Rupees.

Thus the sea bed off Kurrachee dips very much more rapidly than off the eastern angle of the Indus delta, and even more so than off Bombay*.

In its formation, Kurrachee is essentially a back-water harbour, of which the lower and smaller, but deeper, division—comprising the entrance and anchorage—depends chiefly for its maintenance of depth on the tidal flow of the upper and larger, but shallower, division, which constitutes the backwater. The entrance is flanked on the west by the recently constructed breakwater running into five fathoms water, 500 yards S. by E. starting from the base of Manora Point. This headland is 90 feet in height, consisting of stiff clay capped by conglomerate rock (large fallen masses of which help to protect the base), and dipping towards the north-west, until, at a distance of half a mile, it meets a reef nine miles in length, extending to the mainland, and on which the surf has formed a beach, topped by a ridge of blown sand.

On the extremity of Manora Point stands the tower of the new first order revolving light, adjoining the old Sindee Fort (converted into a residence for the master attendant), and one of the lately constructed batteries of 12-ton guns. Lower down on the Point, and on the sandy flat into which it merges on the harbour side, are quarters, workshops, and store buildings of the port, Indo-European Telegraph (harbour station), and harbour works establishments; and, farther on, the quarantine station, and the coaling depôt of the British India Steam Navigation Company.

On the north-west beach, at one mile from the point, stands a second of the recently constructed batteries; and, at $1\frac{1}{4}$ mile farther, a third, as yet unfinished, but designed specially to protect the lower harbour, as deep water comes close in shore. The three battery sites are joined by railway lines, aggregating $3\frac{1}{4}$ miles in length, part of which had been previously made for purposes of the harbour works.† These defences, which Kurrachee owes to the present Governor of Bombay, will, it is understood, eventually merge in a more elaborate scheme of fortification, now in preparation by the Defence Committee under the Government of India.

Eastward from Manora Point to Clifton hill, opens a shallow bay, $3\frac{1}{2}$ miles in width, on the chord of which, at a distance of $1\frac{1}{4}$ miles from Manora, lie the "Oyster rock" islets, which, as well as Clifton, are of stratification similar to that of the Manora headland.‡ From the Clifton shore westward, for a length of $2\frac{1}{2}$ miles, as far as the

* There have been differences of opinion as to the monsoon coast current, which will be found discussed at great length in the printed volumes of Kurrachee Harbour Works correspondence. There can, however, be no question of the steepness of the coast off Kurrachee, and the vitality of the harbour is testified to by the records of accurate surveys extending over 25 years.

† Constructed (excepting the railway lines) by the local officers of Royal Engineers, under Lieut.-Col. J. Le Mesurier, R.E.

‡ A native tradition, discussed at length in the Kurrachee Harbour Works Printed Correspondence, holds that, up to the middle of the last century, a reef connected Manora with Clifton, and that the entrance to the harbour was by a long, narrow channel, about eight miles west of Manora, which was then closed, and the present entrance opened, by an earthquake.

harbour anchorage, the head of the bay is separated from the eastern backwater by the low sandy ridge of Keamari (300 to 500 yards wide), along which runs the Sind Railway, and which is termed an island, owing to its former separation from the Clifton land by the mouth of the Chinna creek, the closure of which formed part of the improvement works.

From Manora Point, the spit called the Bar* runs eastward, and the former exposed entrance channel, only 14 ft. deep at low water, rounded this spit at 1,000 yards from Manora.† Now, however, the bar is cut across near its root, close to Manora, by the new and sheltered entrance channel 20 feet deep at low water, 500 feet wide, and half a mile in length, leading to the lower harbour, which is defined on the east by a stone groyne $1\frac{3}{4}$ miles in length, extending southward from the west end of Keamari Island, and on the west by a sand-bank, extending from Manora to the mouth of the "Tullah" creek, nearly opposite Keamari.

The average width of the lower harbour is about half a mile, its length being rather over two miles, and area at low water 868 acres, of which, however, only about one-seventh part has a depth of from 20 to 50 feet at low water. Even this is at present reduced by eddies to about 80 acres, suitable for anchorage and perfectly sheltered, though in shape not favourable for swinging of the largest vessels at low water.

From the head of the lower harbour at Keamari the shallow backwater spreads out west, north, and east for a total area (at high water spring tides) of 18 square miles, through which branch numerous creeks, and the boat channel, which—leading to the town wharves or "Native Jetty," and tapping the east backwater—forms, with the jetty, part of the improvement works.

From Keamari to the mainland, the backwater is traversed by the causeway called (after its originator) the "Napier" mole, nearly two miles long, forming the road communication with Kurrachee, and near the upper end of which, adjoining the "Native Jetty," is an opening 1,200 feet wide, spanned by an iron screw pile bridge—one of the improvement works—which now passes the tidal flow of the east backwater. The backwater is covered throughout its entire area by high water of spring tides,‡ and drains off for the most part freely at low water, thus constituting an immense natural scouring reservoir for the lower harbour and entrance.

The only river discharging into the harbonr is the Layari, which debouches at the head of the backwater, near the town of Kurrachee, but flows at the most only for a few days each year, when heavy rains fall in the hills. Though at such times this river is of large volume, it is not useful for scour, as it brings down large quantities of sand, which, however, is gradually expelled by the tidal ebb current.

Altogether, the backwater, shallow as it is, and receiving during the S.W. monsoon a copious sand drift from the sea beach, and the detritus washed in by the (occasionally heavy, though infrequent) rainfall round its borders, nevertheless, well maintains its capacity, owing greatly to the action of the strong monsoon winds causing a ripple, and so stirring up material which passes out with the ebbing tide. On the contrary, the flood tide, making round into the harbour from the westward, runs in blue and clear, even during the monsoon, excepting only the local disturbance and eddies caused by the too abrupt ending of the Keamari Groyne.

The range of tide at mean springs is $7\frac{1}{3}$ feet, but at extraordinary tides sometimes so much as about 12 feet. The mean range of neap tides is $3\frac{3}{8}$ feet.

The tidal currents in the entrance attain a maximum of $1\frac{3}{4}$ knots an hour on the flood, and 2 knots on the ebb, but higher up, where throttled by the rocky obstruction called Deepwater Point, they are more violent and irregular, especially on the ebb reaching a maximum of $3\frac{1}{4}$ knots.

As regards weather, violent storms* are unknown at Kurrachee, which, being north, is exempt from cyclones; but the south-west monsoon brings a very heavy sea, lasting with full force for about three months, from the middle of June to the middle of September.

The local wind at that season is generally westerly, and seldom exceeds a strong breeze, with a velocity of about 30 miles an hour, equivalent to a pressure of not more than $4\frac{1}{2}$ lbs. per square foot. The run of the wave is more southerly than the wind, being usually from S.W. by W., having a fetch of 500 miles over a deep sea bottom.

At this time the waves in the deep water at the head of the breakwater attain an observed and frequent maximum of 15 feet in height from hollow to crest, travelling at the rate of 30 nautical miles an hour. Of these high waves, about three-fourths of the elevation is above, and the remainder below, the mean sea-level at the time.

From the middle of October to the end of February is the favourable season for construction of sea works, for though during that time strong easterly winds blow occasionally, they do not bring a heavy sea. The intervals between this fair season proper and the south-west monsoon are subject to occasional squalls, and to strong breezes, chiefly from the westward, raising a sea which is sufficient to interrupt the progress of sea works, though not formidable to navigation.

During the south-west monsoon, for the most part occur the scanty local rains, one or two years sometimes passing with scarcely any fall, and the average being only about 7 inches per annum, even taking into account the unusually heavy falls which occur at intervals of several years, of which the greatest was $28\frac{1}{2}$ inches in 1869, a fall nearly equalled last year (1878).†

Thus the operations of trade are but little interrupted by rain, as compared with most other ports in India, which are subject to heavy and continuous monsoon rains, as for instance, at

* Chiefly sand, but having patches of sandstone rock, boulders, shingle, and clay at its root near Manora.

† There was also a west entrance channel (at about the same place where the new entrance channel has since been formed), having a depth of 11 ft. at low water.

‡ The range of tide is $7\frac{1}{3}$ feet at mean springs, but at extraordinary springs it is sometimes 12 feet.

* The greatest velocity of wind at Manora since 1870 (when observations were commenced) was 62 miles an hour (equivalent to 18 lbs. per square foot), in a squall from N.N.E., which lasted for one hour, on 26th September, 1872. This was quite of exceptionable violence for Kurrachee.

† Instances of extraordinary rainfall at Kurrachee:—In 1851, nearly 26 inches; in 1863, 14·50 inches; in 1866, 13·75 inches; in 1878, 23·82 inches; in 1871, the rainfall was only 0·12 inches.

Bombay, where the average rainfall is more than ten times that of Kurrachee, and last year reached 123 inches.

As regards temperature, Kurrachee compares favourably with most places in India (hill stations of course excepted), for though it has a fierce summer sun, yet the hot weather, say, from May to September, is for the most part tempered by the fresh sea breeze blowing day and night, so that "punkahs" are not a necessary of European life at Kurrachee, as they are at most other places on the plains of India*. And for four months, November to February, Kurrachee enjoys a pleasant and even bracing "cold weather."

The following table shows the monthly average of five years' observations of temperature at Kurrachee (as registered in the shade) for the hottest and coldest months of the year :—

	June.	January.
Minimum	79·68	51·58
Mean	87·95	68·01
Maximum	91·77	73·16

The average mean temperature at Kurrachee during the year (from observations of 19 years) is 77 degrees, about two degress less than that of Bombay, where the cool weather temperature is some degrees higher, though the heavy rains (not without their drawback of steamy damp) shorten the duration of the hottest weather.

As regards health, the great expanse of backwater "slob" left uncovered at each tide, and across which the prevailing wind blows to the city and cantonment, might, to a new comer, appear as noxious as it admittedly is unpicturesque. Experience, however, does not confirm any such first impression, for the great expanse of salt marsh, washed as it is freely by the tide, does not generate malaria, though no doubt some reclamation of its more shallow margins would be desirable on the score of health.

Kurrachee has certainly not been free from occasional severe visitations of sickness, especially in the earlier days of our occupation, when dwellings and sanitation were alike bad, and 'palatial" barracks unknown; yet it is admittedly one of the healthiest stations in India, though still craving an improved water supply, which really now seems likely to be soon provided (after many years of discussion, dating as far back as the time of Sir Charles Napier), and which will greatly benefit the health and appearance of the place, besides being an especial boon to the shipping.

From the above sketch it will be seen that Kurrachee Harbour has, in many respects, been much favoured by nature, and, now that its entrance has been deepened, sheltered, and well lighted, it may be considered very safe and easy of approach ; in fact, there is no Indian port more (if so much) so, as the soundings are regular, and there are no outlying dangers, excepting in so far as that term can be applied to the Indus banks, which, however, need be approached only by coasting vessels, and can well be avoided by proper care and use of the lead. Neither are there formidable currents, and in the only season of hazy and rough weather, *i.e.*, the three months of the (so-called) south-west monsoon, the prevailing wind being from the westward, Kurrachee does not, like Bombay, present the danger of a lee shore.

The number of vessels wrecked or sunk, at or near the harbour of Kurrachee from 1856 to the present time is nine, of which two were river steamers, and seven were sailing vessels. The steamers broke up when leaving the port (before the entrance had been sheltered) owing to their construction being unfitted to stand the ocean swell. Of the number of sailing vessels, five were wrecked owing, more or less, directly to the want of a deep and sheltered entrance channel, and two to that of an efficient light, needs which have been supplied. No seagoing steamer has ever been wrecked at or near Kurrachee, though, since the opening of the Suez Canal, it has been much resorted to by the largest class of trading steamers, as it had long been by those of the British India Steam Navigation Company, which now regularly connect England, the Persian Gulf, and Bombay with Kurrachee.

The history and nature of the improvement works by which Kurrachee has been so far advanced as a safe and convenient harbour, also its further requirements, are now to be briefly described. Previous to, and for some years after the conquest of Sind (in 1843) the harbour of Kurrachee was generally considered as barred against the entrance of other than country craft, though an exception is on record in the case of the two vessels (of a small class, however,) belonging to the H.E.I.C. Marine, by which, in 1809, the mission headed by Mr. Ellis was conveyed to Sind.

Accordingly, in the early years of intercourse with the province, steamers and ships anchored in the roads, outside Manora Point, and there transferred the troops and stores into boats, by which they were conveyed up the harbour so far as the tide allowed, and then again transferred in smaller boats to a spot near the site of the present Customhouse, near the native town.

After a time it was found that the difficulties of the bar had been been somewhat exaggerated, and that vessels of moderate draught could cross it with safety.*

This induced the dispatch of ships direct from England to Kurrachee, and the first of these was the *Duke of Argyll*, a vessel of 800 tons, which arrived in October, 1852, carrying troops and a cargo of coal and iron. After this the port became better known, and the number of ships steadily increased, though the bar continued to be a serious drawback. The first works of accommodation executed in the harbour were the timber pile pier at Keamari (accessible to native craft and to lighters) and the Napier Mole Causeway, two miles in length, connecting Keamari Island with the town of Kurrachee, and the upper part of which afforded a shallow wharfage to native craft. These works were initiated and strongly urged by Sir Charles Napier, the conqueror and Governor of Sind, but were not completed until 1853, during the Commissionership of Mr. (now the Right Honourable Sir) Bartle Frere. Both these works greatly facilitated traffic between the shipping and the town, but the mole affected the harbour unfavourably , by cutting off

* The cost of cooling barracks for British troops in India, by "punkahs" and "tatties," is estimated at fifteen thousand pounds sterling a month during the hot weather. *Vide* "Proceedings U.S. Institution of India," May, 1873, p. 69.

* It is believed that to Captain C. D. Campbell, I.N., belongs the credit of having been the first to take—on his own responsibility—a large armed steamer into the harbour of Kurrachee.

about one-fifth of the breakwater space, and by causing accumulation in the creek leading to the town landing-place. The space thus cut off still communicated with the sea by the "Chinna" creek, the mouth of which became greatly enlarged by the increased scour, and which has been closed as part of the improvement works.

It appears that Sir Charles Napier, from the first, contemplated openings in the mole, which, however, by the advice of his senior naval officer, were not carried out; but the want has since been supplied by the opening and iron bridge already referred to. Sir Charles Napier also contemplated the deepening of the entrance, besides many other improvements of the place, which time and circumstances did not admit of his carrying out. Thus, the general question of the harbour improvement was left to be initiated by Mr. (now the Right Honourable Sir Bartle) Frere, aided by the advice of the local engineers, headed by Major (now General) H. B. Turner, R.E.

A prominent part in the discussion was taken by Mr. Hardy Wells, afterwards the first chief engineer of the Sind Railway Company, who, headed by Mr. W. P. Andrew, have throughout warmly supported the Kurrachee Harbour Works.

After surveys by Commander Grieve, I.N., and much local discussion and inquiry, Major Turner suggested a reference, through the Home Government, to some civil engineer of eminence in the special branch of harbour works.

It is well to record the public spirit and professional liberality evinced in such a recommendation, by an officer whose position might not unnaturally have suggested to him to keep this important project in his own hands. The result was a reference to the late Mr. James Walker, who, in 1858, aided by Mr. William Parkes (who visited Kurrachee in 1857-8, to make local surveys and observations) prepared a design, according to which he estimated the improvement of the entrance and harbour generally at £300,000, and indicated the arrangements of basins, quays, and graving dock at a further cost of £360,000, making a total of £660,000, which he then recommended "to make Kurrachee suitable for an extensive trade in shipping of large tonnage." It may here be remarked that, since 1858, and especially since the opening of the Suez Canal, both tonnage and length of vessels have so increased in scale, that it can be no matter of surprise if the outlay then contemplated by Mr. Walker, to be incurred within six to eight years, be now declared insufficient, while the works, though successful so far, remain still incomplete, after the lapse of nearly 20 years. The works thus designed for the improvement of the entrance and harbour were mainly directed to two objects, namely, to shelter the bar from the heavy seas of the south-west monsoon, and to direct and increase the tidal scour in the harbour and across the bar.

Owing to the financial considerations, and with the very qualified and reluctant concurrence of Mr. Walker, the sanction by the Secretary of State for India in Council was, in the first instance, confined to the works bearing on the scour. This postponment of the breakwater eventually led to greatly increased cost, for it directly checked the full development of benefit from the other works, and thus indirectly also was injurious, as giving a temporary apparent support to objections which were raised during the progress of the works, and besides great delay caused their entire suspension for two years (1866-8).

The works were commenced in 1860, under the superintendence of the author, who has, up to the present time, held charge, excepting two periods of leave, during the first of which (1854-5) Lieut. (now Major) Merewether, R.E., acted for him, and during the greater part of the latter (1874-5) Mr. Hart, M. Inst. C.E.

Up to 1865, the general direction and control was in the hands of the superior officers of the Public Works Department, under strict orders from Government to adhere to the design of Mr. Walker, who, however, did not long survive the commencement of the works, as he died in 1862.

From 1866 to 1868, as already stated, the works were suspended, though the staff continued surveys and observations; and, in 1869, operations were resumed, on the recommendation (after a conference on the spot) of Sir Seymour Fitzgerald, then Governor of Bombay.

From 1868 to 1873, in which year the breakwater was completed, Mr. W. Parkes (who had assisted Mr. Walker in the preparation of the original design) was consulting engineer, the conduct of operations still remaining under the Government of Bombay in the Public Works Department.* Shortly before the resumption of the works, Sir William Merewether became Commissioner in Sind, and throughout his rule effectually and heartily forwarded the harbour works. In this connection also should not be omitted the name of Captain Edward Giles of the (late) Indian Navy, for several years Master Attendant of Kurrachee, whose valuable opinion and unwavering support did much to help the undertaking through its gloomiest days.

The general character of the principal works executed will have been gathered from the description of the features of the harbour already given. These works were all heavy, and in their combined operation constitute a highly interesting piece of engineering; but the breakwater is the only one of them of which the construction presents special interest, when viewed from an European point of view. This work was fully described by the author, in a paper read before the Institution of Civil Engineers,† but a short account of it may now be given. The structure consists of a base of rubble stone (*pierres perdues*) deposited from boats, and levelled off by helmet divers, generally to 15 feet under low water, and on this base concrete blocks, each weighing 27 tons, set on edge, leaning back at a slope of three inches to one foot, and without bond, two forming the width, and three the height, and together making a square of 24 feet in cross section, the top being about the level

* During the progress of the works, the Governors of Bombay were successively Lord Elphinstone, Sir George Clerk, Sir Bartle Frere, Sir Seymour Fitzgerald, Sir Philip Wodehouse, and now Sir Richard Temple. The Commissioners in Sind were successively Mr. Inverarity, Mr. Mansfield, and Sir William Merewether, also recently Mr. Melvill; also Sir Henry Green, Mr. Robertson, and Mr. Havelock each acted for some months, and warmly supported the harbour works. The Secretaryship of the Bombay Public Works Department was successively held by the late General W. Scott, General H. B. Turner, Colonel Kendall, General Sir Michael Kennedy, and now Colonel Merriman, all of the Royal (Bombay) Engineers.

* Minutes of the Institution of Civil Engineers, vol. xliii., session 1875-76, Part I.

of high water. Portland cement, river sand, shingle, and quarry lumps, mixed with salt water, were the materials used for the blocks, the bulk of cement being $\frac{1}{11}$ that of the finished block.

After conveyance from the moulding ground, the blocks were set by a steam travelling crane, called the "Titan," which (running on rails on its own finished work) does not require staging. This machine was devised in consultation between Mr. Parkes and the author, and was made by Messrs. Stothert and Pitt, of Bath. By its means the 1,500 running feet of breakwater was built in three working seasons, aggregating twelve months. The Titan was (with other Kurrachee machinery) afterwards sold to the Madras Harbour Works, where it is now building the north pier, a younger brother giant being engaged on the south one.

The breakwater, which was completed in 1873, has so far well justified Mr. Walker's design of its length and direction, as well as by its stability that of Mr. Parkes for its structure. It suffered some damage during the first few monsoons, but nothing very serious, and it now seems thoroughly consolidated, since the last four monsoons have done it no damage. The superstructure has settled down considerably into the rubble base, as much as 3 to 4 feet in the outer half length, and an additional to player of concrete is being gradually carried forward as a convenience for access, though not as yet required for breaking the sea.

The cost of the breakwater, (including percentage for engineering and office establishments, also share of plant, &c.) was nearly £109,000, being £1,000 less than Mr. Walker's estimate. It should, however, be remarked that the breakwater work coming last, derived much advantage from organisation and training of workmen on the earlier works.

The successful completion of the breakwater and services of the engineers and staff employed on it* were favourably noticed by the Secretary of State for India, the Governments of India and Bombay, and the Commissioner in Sind.

Another smaller, but interesting work, which did not form part of Mr. Walker's project, is the new light on Manora point, the inauguration of which, on 15th August, 1877, was Sir William Merewether's last public act in reference to the harbour works, just before his leaving Sind for the Indian Council. This light will be further referred to in the enumeration of results.

The results so far obtained may be summarised as follows:—

The scour by the groyne, aided indirectly by dredging and excavation at deep water point, and largely by direct dredging on the bar, has formed a direct channel 500 feet in width, 20 feet deep at low water, and half a mile in length, which is sheltered by the Manora breakwater, and through which, according to the official directions for the port† vessels with a draught not exceeding 22 feet, can now pass without difficulty during the south-west monsoon, and during the fair season, up to 24 feet draught, that is two feet more than H.M. Indian troop-ships. This is an increase of 5 to 7 feet during the monsoon, and $4\frac{1}{2}$ to 6 feet during the fair season, as compared with the old directions. It may be added that the draughts thus allowed are really limited more by the capabilities of the anchorage than by those of the entrance, which could pass vessels of much heavier draughts at high water.

Practically, since the capacities for tonnage of different channels vary as the cubes of their depths, and allowing for its greater directness and shelter, the capabilities of the entrance may be fairly said to have been trebled. The formerly frequent and long detention of vessels off the port, and sending them away to Bombay to lighten, are now unknown; the mail steamers are timed regularly, irrespective of tide, and the steam-tug is seldom required by sailing-ships. The shelter of the breakwater also now enables native craft to enter and leave the port during their former close season, the south-west monsoon.

The anchorage has, speaking generally, been deepened, enlarged, and stilled, though much of what was gained at Keamari up to 1869 has been temporarily lost, through the material scoured out from the channel above by the Chinna Creek diversion. As it is, the most marked gain is in the low water area, which has increased from 778 to 868 acres; yet, the perfectly good deep water anchorage area has increased from 60 to 80 acres, and is capable of accommodating 20 vessels of 500 to 2,000 tons register, and even, with special mooring arrangements, so long a vessel as one of H.M. Indian troop-ships, which, it is believed, will work to this port next season, in connection with the newly opened Indus Valley railway system.*

For the native sea-going and general lighterage trade in the upper harbour, a channel has been formed $1\frac{1}{2}$ mile long, 500 to 300 ft. wide, and averaging $5\frac{1}{2}$ ft. in depth at low water, giving access at most times of tide to the "Native Jetty," a work presenting 1,736 ft, of wharfage, adapted to a depth of 10 ft., and 1,070 ft. dry at low water, and comprising an area of five acres. Over this jetty has hitherto passed the great bulk of the trade of the port, the exception being chiefly railway material and Government stores, which are landed at Keamari, where, however, the lately opened Indus Valley State Railway system now calls for more provision for through traffic, of troops and stores as well as produce. Eastward of the jetty, the channel, one mile in length, 290 ft. wide, and $3\frac{1}{4}$ ft. deep at low water at present not only fulfils the one important object of tapping the east backwater, and so directing the scour into the channel below, but it also offers good facilities for the extension of wharfage along it where needed.

In effecting the above improvements, the enor-

* Mr. William Parkes, M. Inst., C.E., consulting engineer. Mr. W. H. Price, M. Inst., C.E., superintendent; Mr. G. W. Lowe, foreman of mason work; Mr. W. Sangster, foreman engineer; Mr. Bhumaya, Saenna supervisor; Mr. J. Humby, sub-engineer. Captain, now Major Merewether, R.E., had been promoted in October, 1870, to the charge of the Bombay defences, after nearly ten years of able and zealous work on the Kurrachee harbour improvements.

† These directions have been framed by the present Master Attendant, Lieutenant G. C. Parker (late) I.N., who has from the first freely worked up to the fullest extent of the harbour improvements.

* The s.s. *Guy Mannering*, length 380 and draught $23\frac{1}{4}$ ft., tonnage registered 2,115, and of cargo 2,817, loaded in Kurrachee Harbour, and left on 24th September, 1876, on a medium tide. Other steamers of similar class, and in one case of 23 ft. 11 in. draught, have loaded here; such, however, have always come in light, been swung at once, and moored head to sea for loading. H.M. Indian troop-ships are 360 ft. long, and draught, loaded, about 22 ft., and, with some special arrangement of available moorings, can even now be safely accommodated.

mous quantity of more than $3\frac{1}{2}$ millions of tons of material (choice sand) has been removed from the entrance and lower harbour, of which one-fourth was effected by dredging, and three-fourths by scour, and from the upper harbour channel more than $2\frac{3}{4}$ million tons, one-third of which was effected by dredging and excavation, and the rest by scour. Adding the two gives over $6\frac{1}{3}$ millions of tons of material removed, or enough to cover 488 acres one fathom deep.* This quantity, large as it is, has probably not more than half exhausted the capability of the scour works for enlargement of the harbour, though they will require several years, and considerable aid by dredging, with some further auxiliary works of no great cost, to develop their full effects.

The Chinna creek diversion especially is as yet far from its full effect, even on the upper harbour channels, and since for their benefit a temporary half-tide weir is still kept up along three-fourths of the length of the Napier Mole Bridge, the improvement of the lower harbour and entrance have so far been considerably retarded by that diversion, which, ultimately, however, will be of great value to them, as it has already been to the upper harbour.

The latest valuable new improvement has been in the substitution of the new first order dioptric revolving light, visible 20 nautical miles during the fair season, and 14 in the south-west monsoon, for the old catoptric fixed light, which, though feebly visible for 17 miles in the fair season, could not in the south-west monsoon be seen at best more than seven miles, and sometimes hardly at all. The value of such an improvement to the mariner needs no remark. It may be added that, owing to the apprehended injury to the light by concussion of the newly mounted guns on the Point, it seems not unlikely to be eventually transferred to Cape Monze (a position preferred by some mariners) substituting a small and easily moveable light on the present tower.

The cost of the works so far executed has been, as already stated, £490,940. The amount might have been considerably less, and the results greater, had the works been carried on in a different order, and without stoppage or delays in execution by short supply of funds.

The above amount includes £12,000 for rectification of the entrance channel (especially the inner end) at the rate of about £4,000 per annum for the last three years, since it was fully formed. This expenditure will be reduced with the help of the new dredging plant now under provision; but, to bring it to a minimum, some further works of no great cost are desirable, which will be referred to presently.† It now only remains to mention what further works are now proposed, the whole of which, however, have not been as yet sanctioned. These include dredging in the entrance, in the lower harbour (especially along east channel), and here and there in the new channel of upper harbour, so as in all to guide the operation of scour, and to aid it especially by the removal of hard material, *i.e.*, shingle and sandstone. Also, to aid the scour, it is proposed to reduce the width of the lower harbour by "groyning" the west side, a work now in progress, as supplementary to the dredging, to accelerate the deepening, which has for some years been steadily in progress, in the east channel of the lower harbour.

The above works, and such further dredging as may be required here and there, to increase the berths for the shipping, will be met from the sanction of one lakh of rupees per annum for dredging, including cost of establishments, which was granted by the Government of India, in 1877, to be expended on dredging for the following ten years, or such other period as future experience may suggest. At the same time sanction was given to the provision of new dredging plant, which is now under construction in England. For this valuable sanction of dredging and plant, Kurrachee owes a large debt to the advice and influence of Sir Andrew Clark, Minister of Public Works in India.

The additional works proposed which have not as yet been sanctioned, are an extension of the east pier (groyne) on a curve for a length of 1,100 feet, for prevention of eddies and shoaling in the entrance channel and anchorage, from cross rush of flood, also for extension of anchorage space for two or three large vessels. Also the reduction of the rocky projection on west side of lower harbour, called "Deep Water Point," so as to lead ebb scour into entrance channel, and to improve anchorage by quieting tidal rush and eddies, and by filling in the deep rocky gut opposite, so as to give berths for two or three large vessels.

Further, two important works of accommodation are proposed, the first of which is an iron screw pile pier at Keamari, fitted with complete appliances in the way of hydraulic cranes, and by means of which one of the largest and two medium sized vessels could discharge or load rapidly, in direct connection with the Indus Valley Railway system.

This work was proposed by the author, as part of the harbour improvements, but seems now not unlikely to be executed as a railway work. Whoever may undertake it, there can be no doubt that it will be profitable, giving greatly needed facilities for transport of troops and stores, as well as for direct up-country traffic in goods and railway material.

The second work of accommodation is a graving dock, for reception of the largest steamers, a requirement which needs but little remark, seeing that the port is quite unprovided with any dock or other appliance for examining or repairing vessels.

The additional works proposed, including the portion of them which has been sanctioned, are estimated to cost a total of £273,858.*

Adding this to what has been already expended, makes a total of £764,798 for the improvement of the harbour, so as to fairly carry out the object

* The cost of the works which have brought about the removal by scour amounts to 7 d. per ton on the quantity as yet removed by their means, whereas that removed by dredging on excavation has cost 1s. $2\frac{1}{4}$d. per ton. The new plant now under provision will reduce the cost of future dredging by about two-thirds; but it must also be recollected that the effects of the scour works are not yet nearly exhausted. N.B.—This is only to January, 1878; the calculations of the survey of January, 1879, have not yet been completed.

† The cost of repairs of the other works, which has not been large, has been also borne partly by Imperial and partly by provincial funds. This is excluded from the statement, which is intended for a comparison only of cost of construction.

* In the calculation provision is included for continuance of the periodical surveys of the harbour, which have been kept up since 1863. For these, as well as for his valuable and zealous services generally, much credit is due to Mr. John Hamby.

contemplated by Mr. Walker, at a cost of £660,000, namely, "to make Kurrachee suitable for an extensive trade in shipping of large tonnage."*

It is true that the basins contemplated by Mr. Walker will not be provided, but the shelter of this harbour is so perfect, that pile piers may—as at Calcutta—be made to serve every purpose of wharfage, and any extension of these the trade will, no doubt, provide as required.

Considering the great increase in size of vessels, and the delays which have ensued, Mr. Walker's estimate has been well borne out by the results.

Further, it may be noted that, up to the present time, his plans have in no case been departed from, except as regards the order and delay of their execution; and the only substantial additions made to them have been in supplementing the effects of scour on the bar and at deep-water point, greatly owing to unlooked for difficulties of hard material.

As regards the important question of ways and means," the expenditure on the Kurrachee harbour works has so far been a charge on Imperial funds, and it is not surprising that this should be so, seeing that only of late years the same ceased to be directly the case as regards the rich ports of Calcutta and Bombay. Arrangements are, however, in progress for increase of the local revenues in support of further expenditure, which must be done by direct taxation of the traffic, since the easy tariff now adopted causes a falling off of customs realisations, in spite of an increasing trade.

For some years there has been a solvent local fund, which meets the expenses of working the port, and has also provided for some minor improvements, and in due time this will, no doubt, develop into a port trust fund, which, after the example of Calcutta and Bombay, will be able to pay the interest on capital expenditure for works.

Such are the history and prospects, so far, of the Kurrachee Harbour Improvements, which it is submitted may fairly be looked on as those of a successful as well as interesting and important work, being also the largest project of general harbour improvements as yet undertaken in India, though much larger sums have been spent on accommodation works in other ports.

NOTE.—The author desires to record his obligation to Majors Colvin and Swinhoe, respectively of the Quartermaster-General's and Commissariat Departments; also to Lieut. Parker and Mr. Bishop, both of (late) I.N.; and to Mr. Cole, Collector of Customs, for information made use of in this paper.

DISCUSSION.

The Chairman said there was a gentleman in the room, who stood really almost *in loco parentis* to this work, Mr. William Parkes, and he would no doubt be ready to answer any questions, or make some further remarks in illustration of the interesting subject before the meeting.

Mr. William Parkes said it was only the engineering aspect of the matter with which he was familiar, although, of course, he had looked at the political and commercial aspects of the question with very great interest. His connection with Kurrachee harbour, dated even from an earlier period than that of the author of the paper. It was now 22 years since he first gave attention to it, and up to a few years ago, it took up a great deal of his attention. Many of those present would hardly be able to appreciate what were the really important results, which had been obtained by these works. As far as the removal of the bar was concerned, that was a very important result, and one which did credit to the engineering of the time. He assisted Mr. Walker in it from an early period, although not from the very first, because to Sir Bartle Frere was due the credit of having, in the first instance, brought the matter before Mr. Walker, when he gave him such local information as enabled him to present to the Government the scheme, which, although he did not at the time pledge himself to it without more professional local examination, was really carried out in its principle features, exactly as he had originally designed it. He did not think even Mr. Price's paper described more clearly what had happened than the original report made by Mr. Walker in 1856, described what he expected would happen, and what had really since occurred. He (Mr. Parkes) went out there in 1857, and spent five months in making local surveys, and when he came home he went into the matter very closely with Mr. Walker, who presented a second report, in which he made recommendations which were approved by the Government, with the modifications which Mr. Price had explained. Only within the last few days a curious circumstance had come within his knowledge in connection with this matter. Last Tuesday evening a paper was read at the Institution of Civil Engineers on the harbour of Dublin, which, although in many respects very different to that of Kurrachee, certainly presented some features in common with it. As he had already said, Mr. Walker gave his original plan for the improvement of Kurrachee in 1856. In 1861, Mr. Walker was consulted about the Dublin harbour, and in this paper there was a quotation from a report which Mr. Walker made in that year. He there said—"I beg to say that the success which has attended the works already executed in the port of Dublin, gives great encouragement to the Corporation to proceed in the same course. There are few, if any, similar cases of a bar and entrance channel to any harbour being increased in depth like that of Dublin, viz., about 7 feet in 30 years, and I think great credit is due to those who designed, as well as to those who executed the works which have achieved so excellent a result." That was almost exactly a description of the result obtained at Kurrachee under the advice which Mr. Walker had then lately laid before the Government. He ought to say that at Dublin the results had even gone a little beyond that. He then described the improvement as 7 feet in 30 years, but in the 18 years which had elapsed since then another 3 feet had been added by the action of the natural scour. He was afraid there was no chance of that being obtained in Kurrachee, because the depth had already scoured down to a hard bottom, and the natural scour would do no more. Seven feet had been gained, and permanently, for there appeared to be no tendency to any material change. That was the great result which had been obtained, and it might not be without interest if he were to briefly recapitulate the means by which that had been done. The extremely useful work, carried out under the authority of Sir Charles Napier, for making a roadway between the landing place and the town, had the effect of cutting off from the harbour about one-fifth of its area. It was part of Mr. Walker's scheme to restore this, and allow all the water to flow in and out at every tide under a bridge made in the line of the Napier moles and so through the harbour. This feature was the subject of a great deal of discussion, and many persons of authority were

* From the *Engineer*, for March 3rd, 1876, it appeared that the Netherlands Government were about commencing, at the cost of the State, a new harbour for Batavia in the Island of Java, at a cost of £3,000,000, especially to provide for the requirements of the Suez Canal trade, which can, however, be more easily met at Kurrachee.

much opposed to it, and in the early stages of the work there seemed some ground for the objections they raised. On the other hand, some of those who supported Mr. Walker laid rather too great prominence on that one feature. The effect of giving the additional scour to the harbour was to increase the size of all the channels, but it also had the effect of increasing really what were the obstructions to the harbour, as a quantity of sand was put in motion which was deposited, not always in the place where it was desirable it should be. On this account, when he became acquainted with the circumstances, he advised that the progress of these diversions should be checked for a time, until the other works had been allowed to develop something more of their results. The first work carried out was the Keamari Groyne, and the effect of that was to cause the whole of the tidal water flowing in and out of the harbour to go into the channel instead of spreading over a great space to the eastward, and thus the channel became enormously increased. The sand washed out was partly deposited on the bar, and the effect was to throw it further to the east, and make the entrance more circuitous than it was before. This convinced the Government they had done wrong in not at once sanctioning the construction of the Manora breakwater. As soon as they were convinced of that, they confided the work to his (Mr. Parkes') general charge, Mr. Price having the local charge of it, and it was at once put in hand. The effect of it was most marked. Although the scour was unable to force a channel through the bar without the help of the dredger, yet whereas before the breakwater was made the dredger could never hold its own, because everything dredged was filled up again in the next monsoon, after the breakwater was completed, whatever depth was dredged out remained, and the channel continued to grow gradually deeper. At first it was only 14 feet, then 17, then 18, and so they got to 20 feet in depth, which had been maintained. Allusion had been made to the fact, that in some respects this harbour was superior to Bombay, and some people supposed it was going to cut out Bombay; but that was a mistake. Bombay would always remain the great port of India, although in some features Kurrachee was certainly superior. He was much struck with this in one respect. When making a voyage from Kurrachee to Bombay, from the time the pilot came on board to take them out of Kurrachee, until he went over the side again, only occupied about five minutes; but in going into Bombay, the pilot was on board more than two hours. The fact was, there was hardly any work for a pilot at all at Kurrachee, the entrance was so open and safe that he really had nothing to do but to point out where the ship ought to be moored. The result of the diversion of the Chinna Creek was now going on. Three or four years ago the results were comparatively small, but they had gone on without any expense, increasing from year to year, and it was marked by the size of the opening under the bridge. In the last report he made to the Government in 1874, he gave the sectional area of the opening as 2,268 feet, but it went on increasing so rapidly, that he found in the last report of Mr. Price, it was 3,719 feet, and this had been accomplished without any expense whatever. This channel, which he now described as having a depth of 5 feet 6 inches, sufficient to carry the great majority of native craft up to the landing place at low water, had formerly no depth at all at low water; in fact, it was dry in its original state. The probability was it would go on increasing, and he had very little doubt that in the course of years, the depth at low water would be 10 or 12 feet, and then at high water even steamers and vessels of considerable size would be able to come up close to the town. Those who understood those matters, politically and commercially, said that Kurrachee had a great future before it, and no doubt that was true, but he believed the physical features of the harbour would keep pace with it, and that it was capable of forming a worthy port to one of the most important parts of India.

The Chairman said that they must all feel very thankful to Mr. Parkes for the additional light he had thrown on this interesting subject, and although he, the Chairman, had at present no special connection with Scinde, yet as it was the land of his adoption, in its name he begged to take the opportunity of thanking him for the time and skill he had devoted to it, and the successful results he had produced. From the very first, he heard of the improvements that were proposed for the harbour of Scinde with great satisfaction. His earliest connection with it was at an after-dinner conversation with Sir Bartle Frere, in the little marine residence called "Clifton," when Mr. Hardy Wells, then engineer of Scinde, was present, and the subject was largely discussed between Mr. Wells and Sir Bartle Frere; things gradually went on until in consultation with Major (now General) Turner, the matter was referred home to Mr. Walker. The result was that Mr. Parkes was commissioned to undertake a survey of the place, and he had the good fortune, in 1858, to go home with Mr. Parkes after the inspection of the harbour, when he heard from him some of the results of his labours. This had culminated in what they had now heard, and he must say that all that had been proposed from the beginning, by Mr. Walker, had been most faithfully carried out by Mr. Parkes, and his coadjutor Mr. Price, the superintendent of the works. Even the very defects which it was thought might occur did crop out, and were remedied as they appeared in the way Mr. Walker himself had suggested, and he was perfectly certain that if it had been ordained that he could have been living, he would have been glad to add his testimony to the faithfulness with which his plans had been carried out. The advantage which had accrued to the harbour, he might say a word upon, because he was one of those who landed in Scinde before it became a British possession. They then anchored about five miles off Manora Point, were carried inside the harbour in ship's boats, and were landed at Keamari, near the channel which Mr. Parkes spoke of, as leading now to the native jetty. It happened to be low water at the time, there was nothing but liquid mud, and there being no mole between Keemaree and the town, they were put into canoes and dragged through this liquid mud by Seedees, slaves of the Ameer of Scinde, that being the only possible means of reaching the town. Now, not only could the native craft go up there, but the steamers with the English mail anchored close to Keamari, and with the pier which was projected, they would go along side it, land the passengers embarked in the London Docks, and from there they could get into the railway, which would take them to Lahore, round to Calcutta, or any other part of India. The great importance of the present harbour consisted in its being the nearest point to England, and probably, for commercial, military, or political purposes, it was the easiest point to get to to send either merchandize or military aid. It was, during the monsoon, much easier and quicker to get there from Aden than to Bombay. Either going or coming, the weather was more favourable, the distance was less by 200 miles, and when you had arrived at Kurrachee, especially in the monsoon, instead of being drenched with rain, you came to a beautiful cool climate with a cloudy sky but no rain. Rain was almost unknown there, except at intervals, and in every respect the climate had great advantages over Bombay. He did not maintain himself that Kurrachee would ever supersede Bombay, or rival it in any way. In fact, the thing was too absurd for anyone who had once been at Kurrachee to suppose. The idea could only occur to people at a distance, who knew a little of one place and nothing of the other, or perhaps nothing of either. One point he might mention would prove that, in a commercial point of view, there was not any rivalry. All the mer-

cantile houses in Kurrachee, with one exception, were branches of houses in Bombay; and why, therefore, they should have branches to rival themselves he could not understand. One was, and would be, a help to the other, and it was very desirable that every step possible should be taken to complete the improvement of Kurrachee harbour, and to open out the communication between that and England, whether it be by the Red Sea, or by the Persian Gulf, and the Euphrates Valley line. Those improvements must be finished, and when they were Kurrachee would certainly take the place Mr. Parkes predicted for it, as a great outport of India. Before sitting down, he would ask the meeting to permit him to convey their thanks to the author of the paper, for the trouble he had taken in sending it to England. Unfortunately, he could not come home with it, because he was devoting himself to the work in which he was engaged. He was appointed to watch over the works in 1860, and, from that time to the present moment, he had continued steadily and zealously to carry out the task entrusted to him. Although there had been several stoppages, great difficulties, and great anxieties, he could say, from having been constantly associated with him, that he had never lost heart, and that natural cheerfulness for which all Irishmen were famous had never failed him. Throughout the whole affair, when most people had been cast down, he steadily maintained that the harbour, which had been so well begun, would be carried through, and that the works must in the end succeed. The Chairman was glad to be able to show, in London, that the scheme had succeeded as far as it had gone, and he trusted that it would continue to do so.

The resolution was carried unanimously.

MISCELLANEOUS.

NOTES ON CERTAIN SILK-PRODUCING BOMBYCES.

By Alfred Wailly.

(Membre en Lauréat de la Société d'Acclimatation de France.)

As many English entomologists now take an interest in European and Exotic Lepidoptera, I send you some notes on silk-producing Bombyces which have been bred in this country during the year 1878:—

Silk-producing Bombyces with closed Cocoons.

Attacus Yama-Mai (Japanese oak silkworm).—This species, reared in England for several years with very little success, is in the egg state during the winter. The moths, which pair with difficulty in confinement, lay their eggs in August and September. About a fortnight after the eggs have been deposited, if fertile, they contain a larva which remains in the egg till the end of April or beginning of May (according to temperature) before it makes its appearance. In warmer countries the young larvæ hatch earlier. The eggs of Yama-Maï must be kept in the open air protected from the rain and the rays of the sun. In case they should hatch before the oak leaves or buds should be sufficiently advanced to feed the young larvæ, small oak trees should be potted and protected from the frost during the winter, but the trees should never be forced in a hothouse. When the young worms have hatched, they can at once be placed on the young trees, and they will seldom wander. When larger, the worms must be placed on oak branches (plunged in water) one or two yards long. Small twigs must not be used, still less cut leaves, to feed the worms. Branches should be cut in the evening, never while the sun is shining on them. If these rules be observed, failure in the rearing of the larvæ will be avoided to a great extent.

For the rearing of young larvæ, I have adopted with great success the following plan:—I have large bell glasses (with four or five openings on the dome) placed on saucers full of sand, covered with a piece of paper. Small branches are stuck through the paper into the sand, and no water is required to keep the foliage fresh under the glass, which, of course, must not be put in the sun. The larvæ will there thrive till they are large enough to be placed on branches plunged in water. When necessary, the glass may be raised so as to give free ventilation; as to the droppings, they can be removed by merely blowing on the paper. If the glasses be large enough, a certain number of the larvæ may be left under them till they form their cocoons, although it is preferable to rear them uncovered when large. When under glass, as no water is required to keep them fresh, the branches may be short, and cut according to the size of the glass, but when plunged in water they must always be long, otherwise the foliage would get watery and cause the death of the larvæ. Yama-Maï worms should not be placed in the open air till June. They want shade, and to be freely watered in hot weather. Ova of this species should always be obtained as early as possible, so that they should pass the winter in the locality where they are to be reared, This plan for rearing the Yama-Maï may be adopted for all the species of silk-producing and other large Bombyces.

Attacus Pernyi (Chinese oak silkworm).—This species, a native of North China, is very easy to rear in the open air, and will feed, like Yama-Maï, on all species of oak. Being double-brooded, and a second rearing in England being extremely difficult, if not impossible, the cocoons obtained should be kept in a cool place, so as to prevent the moths from emerging in the autumn. In spite of precautions, when the autumn is mild, some of the moths will emerge, but the majority of the cocoons will keep till May of the following season.

The young worms of *A. pernyi* hatch in June or the beginning of July, when there is an abundance of foliage to feed them. Besides this advantage over Yama-Maï, it has another—the great facility with which it is reproduced, the moths always pairing in whatever place they may be. The cocoon is larger than that of Yama-Maï.

Attacus Polyphemus (Telea Polyphemus) from North America.—This most valuable insect, which produces a closed cocoon, like the two preceding species, is polyphagous, thriving well on willow, birch, oak nut, chestnut, beech, elm, &c. This species must be considered as single-brooded. It is so in Illinois and Michigan, at least, when the larvæ are reared in the open air.

Several of my correspondents who this year bred *A. polyphemus*, having obtained the moths in the autumn, it must be stated that the cocoons were kept in rooms, which should not be done if they are to be preserved till May of the following year, when the moths begin to make their appearance. It must also be borne in mind that many species of Lepidoptera, which are single-brooded in northern countries, may become double-brooded if bred in captivity, or in warmer countries.

A. polyphemus can be reared in the open air in this country. At the end of last July, previous to a journey I made to Paris, I left a few polyphemus larvæ on small trees in my garden, nut, willow, and birch. On my return to London in September, I was much pleased to see fine cocoons on the trees, although the quality of the foliage was not good.

The larvæ of *A. polyphemus* is most magnificent. In its last stage it is covered with forty-eight silver and eight gold metallic spots, the latter being on the first two segments. When the sun shines on the larva, which is of a fine green, with small pink spines, it seems covered with diamonds.

The fine and strong silk of *Attacus Yama-Maï*, *A. pernyi*, and *A. polyphemus* could be seen at the Paris Exhibition. The silk of *Yama-Maï* is light green,

Pernyi light brown, and *Polyphemus* white. Besides the three species mentioned, there are several others which produce closed cocoons, but as they have not, as yet, been bred in this country, no mention will be made of them.

Silk-producing Bombyces with open Cocoons.

Of these, four species will be mentioned which have been bred in England, France, and Germany, *Attacus cynthia*, *Attacus promethea*, *Attacus cecropia*, *Attacus atlas*, These four species in America go under the generic name of Samia. Cecropia and Promethea also go under the generic name of Hyalophora in America. The larvæ of these four species all have the same form and appearance, and the imagines the same designs on the wings. The moths can all be taken with the hand, and will readily hold to anything, while those of the three species first mentioned, especially Yama-Maï, cannot be held in the hand; the least touch causes them to drop heavily down, and make half a dozen somersaults before they keep quiet. Pernyi, however, is not so wild as Yama-Maï. *Attacus mylitta* (from India) also has the same habits as Yama-Maï. Selene (from India), although belonging to another genus, has also the habit of dropping down when touched, but it will often adhere to the finger.

Attacus cynthia (*Samia cynthia*).—A species acclimatised in France and in the United States of America. Easy to rear in the open air on the ailanthus trees; will feed also, but not so well, on the laburnum, lilac, and cherry. Double-brooded. Moths will often emerge in the autumn, especially if the rearing of the larvac has takenplace early. *A. Cynthia* is a native of North China; the moths pair as readily as those of *Attacus pernyi*, and emerge about the end of June.

Attacus promethea (*Samia promethea*), from North America.—The cocoon of this species is very similar to that of *Cynthia*, but smaller. The moths do not pair easily; the larvæ are rather difficult to rear. Perhaps the proper food-plant has not yet been discovered. The larva in England and on the Continent of Europe has been fed on lilac and cherry. In America, it feeds on the *Laurus sassafras* and *Laurus benzoin*. The male and female moths differ very much in colour, the male being of a velvety black, the female brown.

Attacus cecropia (*Samia cecropia*) from North America. —This species is extremely polyphagous, eating almost any kind of foliage: fruit-trees, especially plum and apple; also willow (all species), poplar, maple, &c. I received in December, 1877, an extraordinary number of live cocoons of *Cecropia* from America (5,500). It has been bred in 1878 extensively in England, France, Belgium, Germany, Austria, and Portugal. I let go from my garden a large quantity of impregnated females, and also took a quantity to a wood near London. Have some of them established themselves in this country?

Attacus atlas (*Samia atlas*, *Saturnia atlas*) from India, China, &c.—Food plants: apple, plum, peach, barberry, &c. Of this remarkable species I could only obtain one brood (pairing), the moths having commenced to emerge only a few days before my leaving London for Paris, at the end of July. The ova I obtained (180) all turned out fertile. Most of the larvæ obtained were bred in France, and some in England. A friend of mine in the country succeeded in rearing all the larvæ (excepting a few which had escaped) in a hot-house, on the barberry. The larvæ formed their cocoons about a month after their exit from the ova—an extraordinarily short time. I saw the cocoons, which were rather small, the larvæ, very likely, having been forced too much. The result of the rearings of Atlas, in France, which I do not know yet, will be stated in the "Bulletins de la Société d'Acclimatation de Paris." I had Atlas cocoons of two different races; the ova were obtained from the smaller race, which, I was told, came from Bangalore. Early in 1877 I had obtained a few cocoons of a giant race of Atlas, which, with similar cocoons I brought from Paris (empty cocoons), happen to be a race from the Himalaya Mountains. These cocoons did not produce a single moth in the summer of 1877, and some of the pupæ died. But this last summer, in July, I obtained a few moths, far more brilliant in colour than the moths obtained from the other cocoons. Two specimens, male and female, are now exhibited, and may be seen in the Insectorium at the Royal Westminster Aquarium, London. The female of this giant race is nearly eleven inches wide from tip to tip of the wings, and is of extreme beauty.

Actias selene (from India.)—This year I succeeded in obtaining four pairs of this magnificent species from cocoons sent from India, June 1st, June 21st, July 4th, and July 5th. I obtained over twelve hundred fertile ova; the first female laid three hundred and fifty ova; the second, two hundred and ninety-six; the third and fourth, about three hundred each. So far as I am aware, the larva of *Actias selene* was unknown in Europe till I introduced it this year. It has been bred in 1878 in England, France, and Germany. From reports sent by different correspondents I heard that many of the larvæ had died in the last stage. The larvæ which I bred on walnut branches until I left London did remarkably well under one of my large bell-glasses till they were nearly full-grown, none having died, when I had to entrust a friend with the rearing of them. Unfortunately, with twenty-four larvæ, he could only obtain two cocoons, which produced two small male moths in September. *Actias selene* feeds very well on walnut, and also on willow and cherry. This species is essentially a "*polyvoltine* race," as we say in French, or "many-brooded." The moths began to emerge on the 28th February, and contiued to do so until the 8th of July, when all the moths had ceased to emerge from the cocoons (38 in number). This long lapse of time from the appearance of the first moth, on the 28th February, till the appearance of the last two on the 8th July, shows the great difficulty I had in obtaining ova of this species; and, if I had not kept a great number of cocoons, in all probability, I should have been unable to obtain fertile ova. Besides the species mentioned, I obtained fertile ova of *Saturnia pyri*, *S. spini*, *S. carpini*; also *Aglia-Eau*, and others; but of these latter I only bred a few *Aglia-Eau*.

CORRESPONDENCE.

TUSSER SILK.

The letter of Mr. F. Maxwell Lyte, in the last number of this *Journal*, seems to call for some remark from me. I quite confirm his explanation of the French "secret," but I fully explained it in replying to Mr. Cobb, and previously, in my paper, p. 510, stated at length the binoxide of barium process of M. Tessié du Motay, which I have had in operation since January, 1876, producing colours quite equal to those on the Continent.

His statement that "Tusser silk seems to take all colours with the same facility as the ordinary silks, even the richest blacks," must be taken in a qualified sense only. So much cannot be expected from it, and although very beautiful colours are now attainable, which were previously impossible, there is a limitation and a great difference, which Mr. Lyte may easily prove by dyeing in the same bath a skein of Tusser silk with one of mulberry silk, especially black.

The bleaching process is not at all necessary for black, nor, in fact, for many good tones of colour. It is only necessary for pale shades.

I have succeeded, by methods of my own, in obtaining

most of the shades best suited to this silk without bleaching, and prefer the results in several important respects, both in my dyeing and printing operations.

The cost of binoxide of barium, 2s. 9d. per lb., is a bar to its extensive use; 30 per cent. is necessary for bleaching, besides a lengthened process. If the binoxide could be sold at 6d. per lb. the process would have more commercial value and application than at present.

THOMAS WARDLE.

St. Edward-street, Leek, 3rd June, 1879.

GENERAL NOTES.

New Steering Apparatus.—Captain T. B. Heathorn has just taken out letters patent for a new arrangement of steering gear, which enables the rudder, or rather rudders, for two are employed, to serve for stopping as well as guiding the vessel. The arrangement it is not very easy to make intelligible without the aid of a drawing, but briefly it is as follows:—There are, as above stated, two rudders, one at each side of the stern, or in close proximity abaft the sternpost. Each rudder is worked by a horizontal slotted lever, in the slot of which there travels a stud, mounted on the end of the tiller. The pivot on which the tiller works is mounted on a nut, carried by a screw set in a direction fore and aft of the vessel. Upon the screw being turned, the nut is carried along, and the stud thereon acting in the slot of the levers, both the rudders are thrown outwards, in fact, the action of the ordinary steering gear, acting through the tillers, is to cause both rudders to move in the same direction and steer the ship, while the action of the screw is to cause the rudders to move in opposite directions, so that they are thrown out from the ship's side and tend to stop her. Captain Heathorn considers the action of the two rudders to be superior to the ordinary rudder from the effect they have on the column of water driven backwards by the screw. A similar arrangement may also be applied to a boat's rudder, but in this case it is worked by the yoke-lines instead of by a screw. Captain Heathorn also considers the mechanical arrangement of this apparatus applicable to many purposes, amongst others, that of loading heavy guns.

NOTICES.

SANITARY CONFERENCE.

The Pamphlet containing a full report of the papers and proceedings of the late Conference on National Water Supply, Disposal of Sewage, and Health, will be published shortly, price 2s. 6d.

Applications for copies of the Report should be addressed to the Secretary.

PROCEEDINGS OF THE SOCIETY.

ADJOURNED MEETING.

The adjourned Meeting for the conclusion of the discussion of the Paper by Mr. Lloyd Wise, on "The Government Patent Bill," will be held on Tuesday, the 10th June, at 8 o'clock.

MEETINGS FOR THE ENSUING WEEK.

MON., JUNE 9TH...Society of Engineers, 6, Westminster-chambers, 7½ p.m. Mr. Charles J. Alford, "The Mineralogy of the Island of Sardinia."

Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. J. Ball, "The Flora of the European Alps, and its connection with that of other regions of the Earth."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. Edward I'Anson, "The Recent Excavations of the Roman Forum."

Social Science Association, and Society for Promoting the Amendment of the Law, 1, Adam-street, Adelphi, W.C., 8 p.m. Mr. J. Leybourne Goddard, "The Law of Copyright, with special reference to the term for the Duration thereof, and the Report of the late Royal Commission with reference thereto."

International Literary Congress (at the HOUSE OF THE SOCIETY OF ARTS) 2 p.m.

TUES., JUNE 10TH...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. (Extra-ordinary Meeting.) Resumed discussion on Mr. W. Lloyd Wise's paper on "The Government Patent Bill."

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor Karl Hillebrand, "The Intellectual Movement of Germany from the Middle of the Last to the Middle of the Present Century." (Lecture V.)

Medical and Chirurgical, 53, Berners-street, Oxford-street, W., 8½ p.m.

Photographic, 5A, Pall-mall East, S.W., 8 p.m.

Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. Miss A. W. Buckland, "Notes on some Cornish and Irish Pre-historic Monuments." Mr. C. Pfoundes, "Some Facts about Japan and its People, &c."

Royal Colonial, "Pall-mall," 14, Regent-street. Dr. J. L. Miller, "Tasmania, Past and Present."

Royal Horticultural, South Kensington, S.W., 1 p.m.

WED., JUNE 11TH...Geological, Burlington-house, W., 8 p.m. 1. Rev. O. Fisher, "A Mammaliferous Deposit at Barrington, near Cambridge. 2. Mr. C. Callaway, "The Pre-Cambrian Rocks of Shropshire." (Part I.) 3. Mr. J. D. Kendall, "The Formation of Rock-basins." 4. Messrs. W. Jolly and J. M. Cameron, "The Occurrence of a Remarkable and apparently New Mineral in the Rocks of Inverness-shire." (Communicated by Prof. J. W. Judd.) 5. Prof. W. Boyd Dawkins and the Rev. J. M. Mello, "Further Discoveries in the Cresswell Caves," with notes on the Mammalia by the former. 6. Mr. R. Mallet, "The Probable Temperature of the Primordial Ocean of our Globe." 7. Mr. W. Percy Sladen, "*Lepidodiscus Lebouri*, a new Species of *Agelacrinites* from the Carboniferous Series of Northumberland."

Microscopical, King's College, W.C., 8 p.m. 1. Prof. Abbe, "A New Method of Correcting Spherical Aberration." 2. Mr. F. H. Wenham, "Note on Prof. Abbe's Apertometer." 3. Dr. Fripp, "The Theory of Illuminating Apparatus employed with the Microscope."

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

International Literary Congress (at the HOUSE OF THE SOCIETY OF ARTS), 2 p.m.

THUR., JUNE 12TH...Royal, Burlington-house, W., 4 p.m. Annual Meeting for the election of Fellows.

Antiquaries, Burlington-house, W., 8½ p.m.

National Education Union, Westminster Palace Hotel, Victoria-street, Westminster, S.W., 11 a.m. Conference of Friends and Supporters of the Voluntary System of National Education.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Karl Hillebrand, "The Intellectual Movement of Germany from the Middle of the Last to the Middle of the Present Century." (Lecture VI.)

Royal Historical, 11, Chandos-street, W., 8 p.m. 1. Miss Helen Taylor, "Some Characteristics of Celtic Settlements on the Borders of the Mediterranean." 2. Dr. Robert Gordon Latham, "Early History of Hungary."

Royal Society Club, Willis's-rooms, St. James's, S.W., 6 p.m.

Mathematical, 22, Albemarle-street, W., 8 p.m. 1. Mr. J. J. Walker, "Notes on the Momental Plane." 2. "A Property of Plane Curves." 3. "A Prize Question of the Belgian Academy of Sciences." 4. Mr. Lloyd Tanner, "Note on Determinants of *n* Dimensions." 5. Rev. Dr. Freeth, "Cases of polygonal Inscription in a Circle."

International Literary Congress (at the HOUSE OF THE SOCIETY OF ARTS), 2 p.m.

FRI., JUNE 13TH....Royal Institution, Albemarle-street, W., 8 p.m., Weekly Meeting, 9 p.m. Mr. Frederick J. Bramwell, "The *Thunderer* Gun Explosion."

Astronomical, Burlington-house, W., 8 p.m.

Quekett Microscopical Club, University College, W.C., 8 p.m.

New Shakespeare Society, University College, W.C., 8 p.m. A Paper by the Rev. Stopford A. Brooke. 2. Rev. B. F. De Costa, "The Genesis of 'The Tempest,'"

SAT. JUNE 14TH...Physical, Science Schools, South Kensington, S.W. 3 p.m. Prof. H. McLeod, "The Suppression of the Induction Disturbance of the Telephone." 2. Messrs. W. Spottiswoode and J. Moulton, "The Sensitive State of Electric Discharges through Rarefied Media." 3. Prof. W. G. Adams, "A New Measuring Polariscope."

Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m

International Literary Congress (at the HOUSE OF THE SOCIETY OF ARTS), 2 p.m.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,386. Vol. XXVII.

FRIDAY, JUNE 13, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Twenty-fifth Annual General Meeting, for the purpose of receiving the Council's report and the Treasurers' statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held, in accordance with the Bye-laws, on Wednesday, the 25th of June, at 4 o'clock p.m.

The Council think it well to call the special attention of Members to the above notice, and to express their hope that Members may find it convenient to attend and receive the report of the Council on the work of the Session.

(By Order of the Council)
H. Trueman Wood,
Secretary.

The Chairman of Council will propose, pursuant to a resolution of the Council (May 12th, 1879), "That a Grant of £100 per annum be made to Mrs. Foster for her lifetime, subject to revocation at any future Annual General Meeting, upon notice being given to the Secretary at least one month previous to such Annual General Meeting."

GENERAL MEETING.—ALTERATION OF BYE-LAWS.

The Council hereby convene a General Meeting of the Members, for the purpose of altering, varying, and revoking the existing Bye-laws of the Society, and making new and other Bye-laws in the place thereof, such meeting to be held on Monday, the 16th day of June, at four o'clock in the afternoon.

Any Member desiring to make himself acquainted with the proposed alterations can have a copy of the Bye-laws, showing the modifications which it is proposed to make, on application to the Secretary personally or by letter.

(By Order of the Council)
H. Trueman Wood,
Secretary.

3rd June, 1879.

CONVERSAZIONE.

The Society's *Conversazione* is fixed to take place at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education) on Wednesday, the 25th of June. The cards of invitation are now in course of issue.

A Vocal and Instrumental Concert, consisting of glees, &c., by the Royal Criterion Handbell Ringers, will be given from 9 to 11 o'clock, with intervals, in the Lecture Theatre.

A Promenade Concert will be given by the Band of the Grenadier Guards in the North Court.

The galleries containing the Raphael Cartoons, the Sheepshanks' Collection, the William Smith Collection of water-colour drawings, the Dyce and Forster pictures, the Collections of Paintings lent by Lord Spencer and by the trustees of the late Rev. Pryce Owen, "The Chantrey Bequest," and Schliemann Collection of objects from Troy, will be open.

The courts and corridors of the ground floors will be open. The reception will be held in the throne room of Akbar Khan in the Architectural Court, by Lord Alfred S. Churchill, Chairman, and other Members of the Council.

PRACTICAL EXAMINATIONS IN MUSIC.

An examination for candidates residing in or near London has been arranged to be held at the House of the Society of Arts next week.

The examinations will be exclusively practical, and will take account of voice, style, ear, and reading.

Candidates in vocal music will be required—

1. To sing a solo, or to take part with another candidate in a duet, already studied. Credit will be given for the choice of the piece sung.

2. The pitch of a key-note being given, to name sounds or succession of sounds, played or sung by the examiner in that key and in the keys connected with it; *e.g.*, the dominant, subdominant, relative minor, or other.

3. To sing or solfa at sight passages selected generally from classical music.

Candidates in instrumental music will be required—

1. To play a piece already studied. Credit will be given for the choice of the piece played.

2. The pitch of a key-note being given, to name sounds, played by the examiner in succession or in combination, in that and its relative keys.

3. To play a piece or portion of a piece at sight.

The maximum of marks is 100. These will be distributed among the subjects of examination in the following proportion:—

Vocal Music.

Voice	20 per cent.
Style	20 ,,
Ear	20 ,,
Reading	40 ,,

Instrumental Music.

Execution	20 per cent.
Style	20 ,,
Ear	20 ,,
Reading	40 ,,

Candidates who obtain 75 marks will be entitled to a first-class certificate; and those who obtain 50 to a second. Candidates, the number of whose marks is below 30, will be entered as "not passed."

Before admission to the examination, all candidates must have sent in a certificate, from a professor or other musical authority, to the effect that their qualifications are such as to afford a reasonable chance of their passing. Vocal candidates must come provided with a second copy of the solo or duet they have studied, in the established notation.

An accompanyist will attend the examination for vocal music, but candidates who prefer to do so, can bring an accompanyist with them.

Each candidate must pay a fee of 5s.

The examination will take place in the day or evening, according to the convenience of each candidate.

AFRICAN SECTION.

Tuesday, May 27th; Arthur Mills, Esq., M.P., in the chair.

The Chairman, in introducing Mr. Hutchinson, said he felt that England had a very great responsibility towards Africa, because her relations with that country, even up to less than a century ago, were of a very questionable character; that is to say, we were abetting the slave trade at those stations which, happily, were now used for very different purposes, on the West Coast. At the time of the infamous treaty under which England and Spain shared the profit of the slave trade, we incurred a debt to the population of Africa of a most serious kind. That which constantly presented itself to his mind with reference to Africa was, that we, who had settlements on the west, the east, and on the south, had also an enormous native population within the borders of British territory, vastly out of proportion to the European population. Indeed, taking the British Empire all round, the coloured population was as large as 30 to 1 of the European; under these circumstances it was a matter of immense difficulty for England to know how to discharge her duties. She had experienced that difficulty very greatly of late, with reference to South Africa; and although it was not his intention to make any speech on that occasion, he could not help using the opportunity to say that he thought a very distinguished man, a valued friend of his own, who was now administering the affairs, and conducting, under circumstances of enormous difficulty, a duty of immense responsibility in South Africa, had scarcely been used fairly by some portion of the British public. He could not help saying this, not only because Sir Bartle Frere was absent and was a personal friend, but because he felt that he was one who desired, so far as he could to do his duty as representative of the British Crown, in dealing, in a spirit of Christian civilisation, with the vast native population with which we were brought in contact in that portion of the world. One important point to which Mr. Hutchinson would call attention, was that this very tribe of Zulus with whom we were now brought in contact, were descendants of a race with whom the Portuguese were brought into conflict in a serious manner nearly 200 years ago. Another thing which must press itself on the mind of every one who looked at the position of things in Africa, was that our differences there were enormously multiplied by the circumstances that other nations, partly the Portuguese and Dutch, had preceded us, and the policy which had been pursued towards the native races by them had sown the seeds of difficulty, of which we were now reaping the fruits.

The paper read was—

THE CONTACT OF CIVILISATION AND BARBARISM IN AFRICA, PAST AND PRESENT.

By Edward Hutchinson.

There is probably no race of man or group of races which, through many long ages, has remained so entirely unaffected in the mass by external influences as the inhabitants of intertropical Africa. Nor is there any so considerable a portion of the earth's surface which remains in practically virgin solitude at the present time.

This condition of barbarism, or semi-barbarism, and isolation, seems to have been the characteristic of Africa from earliest times, and yet the Continent has been attacked on every quarter by the pioneers of the civilisation of every age, and of each successive type.

The great powers who, in succeeding ages, have contributed paragraphs or chapters to the history of civilisation, have more or less been brought into contact with Africa, but while their actions, their influence, their teaching, have resulted in that civilisation which affects more or less the whole remainder of the globe, Africa, as a continent, remains a mass of barbarism. Of these powers the chief are Egypt, Carthage, Rome, the Moors, Arabia, Portugal, France, Holland, and England; and (as the limits of my paper will not admit, nor could I pretend to an exhaustive treatment of my subject) I propose to state shortly some of the chief characteristics, which have attended the contact of the civilisation of these nations with the barbarism of Africa, and then seek to deduce some general conclusions, which may assist in forming an estimate of the success which may be looked for in any large attempt to introduce civilisation and commerce into the dark continent.

I have already, in discussions in this room, stated my conviction that Africa may very appropriately be termed a lost continent, in reference not so

much to its condition of degradation and darkness, as to the fact that, two centuries ago, there was a fair knowledge of the interior of the continent, the result of the inquiries, travels, and expeditions of various nations.

In considering the various instances of the contact of civilisation with the barbarism of Africa, I think we shall be struck at the outset with the fact that, whereas in every other part of the globe civilisation, by mere contact, apparently has planted offshoots which reproduce not only its vices, but also its virtues, the soil of intertropical Africa seems incapable of receiving or nourishing the better germs of civilisation. I do not mean to suggest that the expeditions or explorations I am about to refer to were all undertaken with the object of benefiting those with whom they came in contact, but, still, their promoters had pretty much the same purposes in view as those which have led to the discovery of new worlds, and the foundation of empires, states, and colonies.

For the apparent failure in Africa of that which has succeeded elsewhere, we shall, I think, find the causes partly in the character and circumstances of the nations whose civilisation met the barbarism of Africa, but chiefly in those conditions of climate and general aspect of nature, which, while they everywhere influence man in his social condition, do so in a very marked and special manner in intertropical Africa, the area with which I propose to deal, a preliminary inquiry into this branch of our subject may serve as a useful introduction.

The first record we have of African travel is to be found in the narrative of Herodotus, but this author does no more than retail such information as appears to have been gathered by the Egyptians as to the interior of Africa. This historian supplies us with no record of conquering or colonising expeditions undertaken by Egypt, and yet the civilisation of that remarkable race must have, in some form or other, come into contact with the barbarism of the Soudan. Indeed, it seems difficult to suppose that a people, the monuments of whose grandeur strike the modern traveller with awe, and whose warlike reputation stood high among the nations of antiquity, did not make that power felt in the subjugation of the southern barbarians of that day. It is difficult to imagine a country so densely populated, and so wealthy, exercising so little activity beyond its own narrow limits. According to Mr. Buckle ("History of Civilisation," p. 88, vol. 1), Egypt was not only far more thickly peopled than any country in Africa, but probably more so than any in the ancient world. Herodotus and Diodorus Siculus agree in putting the number of inhabited cities at 18,000 or 20,000. Speaking of ancient Egypt, Mr. Buckle says (p. 49, vol. 1):—"In that spot wealth was rapidly accumulated, the cultivation of knowledge quickly followed, and this narrow strip of land became the seat of Egyptian civilisation, a civilisation which, though grossly exaggerated, forms a striking contrast to the barbarism of the other nations of Africa, none of which have been able to work out their own progress, or emerge in any degree from the ignorance to which the penury of nature has doomed them." Yet no trace remains of any attempt at expansion or conquest. On the contrary, the power and civilisation of Egypt seems to have been confined to the narrow limits of modern Egypt, a slip of land averaging a width of only nine miles. The reason may be found to lie in the operation of physical laws on Egypt as a nation, and then in the general aspect of nature in the adjoining country to the south.

The limits of ancient Egypt and modern Egypt were alike fixed by the same natural phenomenon, viz., the overflow of the Nile. The factors, so to speak, must have been the same then as they are now. That combination of rainfall, accumulating marsh, and overheated and decaying vegetation which Sir S. Baker, Col. Gordon, and the Egyptian engineers of modern times have had to meet and overcome in cutting a way from Khartum to Gondokoro, must have presented insuperable obstacles to any attempts unaided by scientific auxiliaries. On the other hand, this phenomenon, as wondrous in its regularity as in its results, had and still has a most important bearing on the nation as a whole, for it has been the chief agent in producing that cheap and abundant supply of food which resulted in an over-supplied labour market, and its concomitant unequal, division of wealth and power.

The two Greek authors quoted are both agreed respecting the rapid increase of the people and the servile condition into which they had fallen. Thus the very beneficence of nature becomes an element of weakness, and the possession of such cheap and plentiful food as dates, rice, and dhourra, combined with the high rate of temperature, tended to the rapid multiplication of a race, destined thereby to hopeless slavery. Diodorus Siculus states, that to bring a child up to manhood did not cost more than 20 drachmes, or 13s. English money. According to Mr. Buckle, the vast monuments of Egypt could only have been erected when the industry of the whole nation was at the command of a few. In no other circumstances could human life have been squandered with the recklessness which the standing monuments of Egypt bear witness to. According to Herodotus, 2,000 men were occupied for three years in carrying a single stone from Elephautine to Sais. Wilkinson states that the Red Sea Canal cost the lives of 120 men, and Diodorus tells us that to build one of the pyramids required the labour of 360,000 men for 20 years.

I have dwelt at some length on these aspects of Egyptian civilisation, as they have an important bearing on that part of my subject which deals with the influence exercised on the social condition of man by physical laws and the general aspect of nature. This appears a suitable place to introduce some remarks in support of this part of the subject, which may well serve as introductory to, and explanatory of, those episodes of African history which I have selected to illustrate my subject.

Mr. Buckle, in his "History of Civilisation," lays down the proposition that, in the early stage of society, the powers of nature exercise a remarkable influence over the fortunes of man. His arguments, in support of this statement, have so direct a bearing on my subject, that I venture to quote at some length from his introductory chapters. He says (chap. ii, vol. 1.) "the physical agents by which the human race is most powerfully influenced may be classed under four heads, namely, climate, food, soil, and the general aspect of nature. To one of these four classes may be

referred all external phenomena by which man has been permanently affected." The first three agents, climate, food, and soil, have originated the most important consequences in regard to the general organisation of society, and from them there have followed many of those conspicuous differences between nations which are often ascribed to some fundamental difference in the various races into which mankind is divided.

Mr. Buckle considers such original distinctions of race to be altogether hypothetical, and adds a cordial assent to a remark of John Stuart Mill, that, of all vulgar modes of escaping from the consideration of the effects of social and moral influences on the human mind, the most vulgar is that of attributing the diversities of conduct and character to inherited natural differences. He states, of all the results which are produced among a people by their climate, food, and soil, the accumulation of wealth is the earliest, and, in many respects, the most important; for although the progress of knowledge eventually accelerates the increase of wealth, it is, nevertheless, certain that, in the first formation of society, the wealth must accumulate before the knowledge can begin. As long as every man is engaged in collecting the materials necessary for his own subsistance, there will be neither leisure or taste for higher pursuits; no science can possibly be created, and the utmost that can be effected will be an attempt to economise labour by the contrivance of such rude and imperfect instruments as even the most barbarous people are able to invent.

In a state of society like this, the accumulation of wealth is the first great step that can be taken, because without wealth there can be no leisure, and without leisure there can be no knowledge. If what a people consume is always exactly equal to what they possess, there will be no residue, and, therefore, no capital being accumulated, there will be no means by which the unemployed classes may be maintained. Thus it is that, of all the great social improvements, the accumulation of wealth must be the first, because without it there can be neither taste nor leisure for that acquisition of knowledge on which the progress of civilisation depends.

The great physical causes by which the creation of wealth is governed, will be found to depend entirely on soil and climate; the soil regulating the returns made to any given amount of labour; the climate regulating the energy and constancy of the labour itself.

But another point of equal, or perhaps of superior, importance remains behind. After the wealth has been created, a question arises as to how it is to be distributed. In a very early stage of society, and before its later and refined complications have begun, it may, I think, be proved that the distribution of wealth is, like its creation, governed entirely by physical laws; and that those laws are, moreover, so active as to have kept a vast majority of the inhabitants of the fairest portion of the globe in a condition of constant and inextricable poverty.

Bearing in mind these preliminary remarks, let us proceed to a review of the contact of civilisation with the barbarism of Africa.

I have already shown that, as regards ancient Egypt, the operation of the physical laws we have considered resulted in a social and political condition entirely opposed to all external progress.

The first country, then, whose history comes into contact with that of intertropical Africa is Carthage. Among all the great nations of antiquity the Carthaginians were the most distinguished for their commercial enterprises. Their ships frequented almost every port in the Mediterranean, and sometimes they found their way even to the barbarous shores of England and Ireland. They planted colonies in all parts of Northern Africa, had highways for commerce with Egypt and Ethiopia, and they are known to have had commercial intercourse with people living south of the Great Desert. The historian, Pomponious Mela, relates that, on a pillar in the City of Carthage, was inscribed a narrative of the expedition of Hanno; this consisted of 60 ships of 50 oars each, and 30,000 persons of both sexes, with ample provisions and everything necessary for so great an undertaking. The object of the expedition was three-fold, viz., to explore the country, found colonies, and promote commercial speculations.

The expedition having cleared the Pillars of Hercules, sailed two days along the coast, and founded their first colony, which they called Thymatirum. Further on, they founded five small colonies near to each other. The next important point in their voyage—but we are not informed how long they were in reaching it—was the great River Lixus, on the banks of which they found a pastoral people whom they called Lixitæ. They seemed to be a mild and quiet people, and treated the Carthaginians with much kindness. In the same region they found Ethiopians of a much less hospitable character. They were also told that there were Troglodytæ dwelling in the mountains, where the Lixus took its rise, who were fleeter than horses. Having procured Lixitæ as interpreters, they continued their voyage three days further, and came to a large bay, where they founded a city and called it Cerne. Here they judged themselves to have sailed as far from the Pillars of Hercules as it was from that place to Carthage.

After recruiting, they resumed their voyage and sailed along the shores for twelve successive days. The inhabitants along this region were Ethiopians, whose language the Lixitæ interpreters did not understand. They always fled at the approach of the Carthaginians, and it was impossible to have any intercourse with them. Having held on their way two days farther, they came to an immense opening in the sea (probably a large bay), on either side of which they saw fires at night rising at intervals in all directions. Having replenished their stock of water here, they continued their voyage five days farther, and arrived at a large bay which their interpreters said was called the Western Horn. In this bay they found a large island, in the centre of which was a salt lake with a small island in it. When they went ashore in the daytime they saw no inhabitants, but at night they saw fires in every direction, and heard a confused noise of pipes, cymbals, drums, and shouts, and being greatly frightened, their diviners advised them to leave the place as speedily as possible. The farther they went, however, the deeper they plunged into mystery. They soon found themselves abreast of a country blazing with fires, streams of which

seemed to be pouring from the mountain tops into the very sea. Having proceeded four days farther, they came to a country which seemed to be in a universal blaze at night, and at one point the fire seemed to blaze up to the very stars, which they were told was the chariot of the gods. Three days more brought them to another bay called the Southern Horn. In this bay was a large island filled with savage inhabitants, the greater part of whom were women. Their bodies were hairy, and their interpreters called them *Gorillæ*. They attempted to seize some of the men, but they escaped out of their hands to the rocky precipices, and defended themselves with stones. They secured three of the females, but found them so unmanageable that they put them to death and preserved their skins.

Here their voyage terminated. Their provisions became so low that they were compelled to retrace their steps.

No nation has had a larger share of dealings with Africa than the kingdom of Portugal; her early discoveries seemed to place within her grasp a dominion in Africa unrivalled in extent. Its coast line on the west stretched from Cape Lopez just to the south of the equator, to Cape Frio in 18° south latitude, and on the east coast from Delagoa Bay to Mombasa. In the words of Captain Burton, in his introduction to the "Lands of the Cazembe"—

"* * The Portuguese * * in the sixteenth century, established factories on both coasts, eastern and western; their traders crossed the interior from shore to shore, whilst their missionaries founded large and prosperous colonies, such as Zumbo in the east, and Salvador in the west, with cathedrals, churches, chapels, and storehouses. The explorers did not neglect either the Lake Regions of Central Inter-tropical Africa, or even the basin of the Zambesi River."

From Mr. Major's most interesting work, "Prince Henry the Navigator," from Pigafetta's "Relatione del Reame di Congo," written in 1591, and from the chronicles of the Mozambique, translated by the late Captain Elton, I gather the following epitome:—Early in the 15th century, that "last of the dark ages," Prince Henry of Portugal—by his mother, Queen Philippa—grandson of old John of Gaunt and a child of England, set before himself the discovery of a sea-path to India, and initiated that wonderful series of maritime explorations during four centuries and a half, which led to the discovery of the mighty continents where England has an empire on which the sun never sets.

The discoveries of the Genoese were made use of by the prince in directing his earlier expeditions. These felt their way step by step from Madeira to the Canary Islands, the Azores, thence to the mouths of the Senegal and Gambia rivers; while the important discovery, that at Cape Verde the land trended to the east, decided the King of Portugal to continue expeditions for the discovery of a sea passage to India.

The death of Prince Henry, in 1460, somewhat checked the progress of discovery, but still the work went on, a gradual advance was made southwards along the African coast, the Fort of Elmira was built, and stone pillars ornamented with crosses were put up at various points. In 1484, Diego Cam reached a mighty river, on the south side of which he set up a cross, and called the river the Rio de Padrao. The natives called it Zaire, and it was afterwards called the Congo from the country through which it flowed.

Further stimulus was given to the effort at discovery by the reports which reached the King of Portugal, of a powerful sovereign who lived a thousand miles away in the interior, and held temporal and spiritual dominion over all the surrounding kings. The accounts received of this monarch, the King of Ogane (Uganda ?) tallied with the description given of Prester John, and the king lost no time in sending two missions, one to reach the court of that monarch by Jerusalem and the east, and the other by following the supposed easterly direction of the African coast. Pedro de Covilham reached the Red Sea, sailed from Aden to the Malabar Coast and passed on to Calicut and Goa, thence he crossed the Indian Ocean to Sofala on the east coast of Africa, and gathered intelligence as to the Island of the Moon, now Madagascar. On his return he sent letters to the King of Portugal, stating that the ships which sailed down the coast of Guinea would reach the termination of the continent by sailing south.

In the meantime the expedition of Bartholomew Diaz had sailed. Making directly for the south they passed the southern limit of discovery, and pushed on against baffling winds to the south of the Orange River; from this point they were driven south by tempest for thirteen days. When the wind abated Diaz steered eastward for the shore, but finding no land, he altered his course for the north and made land at what is now Flesh Bay near Mossel Bay. He had rounded the Cape without knowing it. He ultimately reached the Great Fish River in longitude 28 east; on his return he sighted the rocky headland which forms the southwest point of the great continent, and in memory of the tempest he encountered there gave it the name of the Cape of Storms, a name which the King of Portugal refused to ratify, and substituted the more auspicious title of the Cape of Good Hope.

The full advantages of the discovery of Diaz were realised two years afterwards by Vasco di Gama, the result of whose journey was the gradual establishment of the Portuguese power at various points on the African and Indian shores of the Indian Ocean. Thus, about the end of the 15th century, we find Portuguese factories, and indeed colonies, on both shores of the African continent, between the 20th and 15th parallels of northern and southern latitude on the western, and the 5th and 25th degs. on the east coast.

The two chief points at which they established themselves were, on the west coast the vicinity of the Congo, and on the east, Mozambique. The historian of Mozambique and its dependencies, as translated by the late lamented Captain Elton, states "that from the year 1505 dates the commencement of Portuguese colonisation in East Africa," adding, "we shall see how, from this weak stockade, roughly erected on the mouth of an unimportant river, our dominion extended for hundreds of leagues in shore, and into the interior of this country of mines and most fertile lands." So rapid was the rise of Portuguese power in the east, that, in the year 1569, it was found necessary to divide the numerous territories, which Portugal

professed to rule, into three governments, one was to comprise the conquests on the East African coast from Delagoa Bay to Cape Gardafui, and another those on the northern and eastern shores of the Indian Ocean, and the third was to stretch from Ceylon to China. To the African Government was appointed the famous Francisco Barreta, with the additional title of "Conqueror of the Mines of Monomotapa," a country, according to Pigafetta, lying to the south-west of the Zambesi, and abounding with mines of gold. Led by the hope of reaching these mines, and the idea of connecting, by a road across the continent, the Portuguese possessions on the west and east coasts, Baretta undertook an expedition to Monomotapa. It reached Sena after much privation, and a further advance was attempted but failed, and Barreta died while making a second attempt to advance. Under his successor some mines, supposed by Captain Elton to have been the quartz workings in the north of the Matabele country, were reached, but, according to the Portuguese chronicle, so great was the disappointment of the Portuguese when they saw the hard work and little profit which would attend the working of these long coveted mines, that the governor resolved to retire. Subsequent efforts to grasp this prize, and also to cross the continent, were made, abortive attempts which consumed and wasted the strength and time which should have been employed in consolidating and settling the unwieldy fabric of Portuguese power.

A different spirit altogether seems to have prevailed here from the noble sentiment which animated the earlier explorers on the West Coast, "Talent de bien faire," the motto of Prince Henry, was adopted by the men selected by him and by King Alfonso for the work of African discovery. In the later expeditions to the East Coast, we read of no crosses being erected at each point of discovery. The lust of conquest or the search for fabled wealth seems to have produced its usual degrading effect. The chronicler says the people cared for nothing but the tribute of gold, ivory, and slaves, while the voluptuous lives of the governors and higher officials soon resulted in so low a standard of morality as to become almost a proverb.

In 1710 Lacerda, the Governor of Mozambique, thus describes the life of his predecessors in the so-called golden times. "They did not move out of their houses except in sedan chairs, and with two great velvet umbrellas, with large handles of silver, held on either side, so that the rays of the sun, already nearly setting, should not injure them. They lived enveloped in silk and the finest white muslins, often suffering from attacks of indigestion and colic, the result of their splendid and profuse living; and, finally, they spent their time in scattering goods and collecting gold and ivory."

The chronicler of Mozambique thus describes the moral condition of the colony:—

It is a notable fact that from this day henceforth, almost up to the present, all the Governors of Mozambique beg with persistence to be relieved after their first year of government, repeating their requests in each monsoon with complaints of ill-health, and the privations to which they are put from the reduction of their salary, some even adding that it is impossible not to be robbers on such small pay in so expensive a country; but when they die they leave large estates, and if they live, return rich to the kingdom, the denunciations with which each one of them honours his predecessor being the step which exalts his own clean hands to the clouds.

The immorality which has existed in all our colonies has never, in any of them, obtained to such a high degree as in Mozambique. On the death of the first Secretary to the Government in 1766, the Captain-General writes to the Court that he will not name another Secretary, because he has not met in Mozambique with a man of probity and honour. At the same time an *employé* of the Treasury is sent to Lisbon under arrest accused of a thousand crimes, the property of a secretary in charge of the Government is sequestrated, he being accused of robbery, taking bribes, and extortion, and putting up the Governor's house and furniture for sale by auction. The important mart and town of Zumbo is reduced to misery through the sedition and intrigues of the Dominican Fathers. Such a confusion in the factory of Sena that it was declared impossible to furnish a return of the Crown lands of that district. An Auditor-General, tyrannical, ferocious, and a robber, flying like a convict after forging a will, and a thousand other cases of disorder and degradation.

To all the other miseries which the Portuguese seem to have inflicted on the East African coast, they added the horrors of the export slave trade.

They had commenced soon after their establishment in Brazil a slave trade from the West Coast, but, in 1645, the kingdom of Angola, whence they drew their supplies, having fallen into the hands of the Dutch, who were established at the Cape, the Portuguese commenced that export trade from Mozambique, which continued down to our own times, and the ravages of which aroused the indignation and resentment of David Livingstone and the English people. From that date the Portuguese chronicle is a record of successive reverses, disasters, and encroachments at the hands of the Kaffirs, the Turks, the Dutch, the French, and the Arabs, until at last on both east and western coasts the Portuguese simply existed, their power and prestige gone.

The completion of the story of the contact of civilisation under the Portuguese with the barbarism of Africa, is found in the pages of Livingstone.

He says, in reference to the answer put forward by the Portuguese Government to the statement made by him at the meeting of the British Association, at Bath, in September, 1864:—

The main object of the Portuguese Government is not geographical. It is to bolster up that pretence to power which has been the only obstacle to the establishment of lawful commerce and friendly relations with the native inhabitants of Eastern Africa. I may add, that it is the unwarrantable assumption of power over 1,360 miles of coast, from English River to Cape Delgado, where the Portuguese have, in fact, little authority, which perpetuates the barbarism of the inhabitants. The Portuguese interdict all foreign commerce, except at a very few points where they have established Custom-houses, and even at these, by an exaggerated and obstructive tariff and differential duties, they completely shut out the natives from any trade, except that in slaves. They pay tribute to the Zulus for the land they cultivate on the right bank of the Zambesi, and the general effect of the pretence of power and obstruction to commerce is to drive the independent native chiefs to the Arab dhow slave trade as the only one open to them.

On the West Coast, the Portuguese have carried

on trade from Loanda and other ports, and they have, with the other nations trading there, joined in supplying cheap arms and ammunition, and enormous quantities of spirits to the natives.

Stanley relates a characteristic incident which occurred to him, as his party, hunger-stricken and perishing, neared the coast. He says :—

About a mile from Muato Wandu we appeared before a village, whose inhabitants allowed us to pass on for a little distance, when they suddenly called out to us at a shrieking pitch. The old chief then hurried up and sat down. In a composed and consequential tone he asked, "Know you that I am the king of this country?" I answered mildly, "I knew it not, my brother." "I am the king, and how can you pass through my country without paying me toll?" "Speak, my friend, what is it the white man can give you?" "Rum! I want a big bottle of rum, and then you can pass on." "Rum?" "Yes, rum; rum is good, I love rum," he said, with a villanous leer. Uledi, the coxswain, coming forward, impetuously asked, "What does this old man want, master?" "He wants rum, Uledi, think of it!" "There's rum for him then," he said, irreverently slapping his majesty over the face, who, as the stool was not very firm, fell prostrate.

We may, I think, conclude that the contact of Portugal with Africa has not been productive of civilising effects.

The Mohammedan next occupies our attention. The eighth century of the Christian era saw the rise of a power which was to play a most important part in the political history of Africa. A race of pastoral barbarians (Dickinson, *Journal of Asiatic Society*, vol. v. p. 323), inhabiting the arid wastes of Arabia, termed by the Persians "a band of naked lizard-eaters" (Malcolm's "History of Persia"), over-ran and conquered Syria, Persia, Northern Africa, Spain, Asia, Minor Turkey, and the whole continent of India. Throwing off the rude barbarism from which they had emerged in their new settlements, their character seemed to undergo a complete change. Now, for the first time, they became able to accumulate wealth, to make progress in the arts of civilisation, and then to extend the influence of that civilisation, such as it was, into the continent of Africa.

This influence has penetrated the continent in three directions. From the North, under Moorish rule, across the Sahara, to the great Valley of the Niger, and along its banks to the northern shores of the Binue and Shary Rivers; from Egypt along the White Nile, and westwards through Darfur to Wadai, and from the more modern Arab settlements on the East Coast into the very heart of the continent at the Victoria Nyanza, across Lake Tanganyika to Nyangwe; and from Kilwa to Lake Nyassa.

Whether in these days it is admissible to regard Mohammedanism in any form as a civilisation is a difficult question. Four or five years ago, a party arose who seemed to claim for Mohammedanism the status not only of a civilising power, but a power whose form of civilisation was especially adapted to the wants of Africa, and the extension of Mohammedan influence in Africa was advanced in support of this opinion.

With regard to the North, the travels of Gray and Dochard, Park, and Lieutenant Mage seem to show that the character of the people along the course of the Niger, and in the great cities of Sego and Timbuctoo, is not unlike that of the Arabs around Algiers and the Kabyles, or nomad races of North-Western Africa. The original races, partly nomad, partly agricultural, were originally pagan; they have been subdued, and are now professedly Mohammedan. What the attendant circumstance of the contact of this pseudo-civilisation with the barbarism of this part of Africa have been, we know not, but if we may judge the more remote by the more recent past they probably were those which generally have attended the extension of Mohammedanism or the exercise of its power. A remarkable illustration of this is afforded by the comparatively recent rise and extension of the Foulah power.

About the year 1818, by the zeal of the ruling *walis*, the doctrine of the Prophet had become the national creed of Futa land, the Fulbe, in obedience to the dictates of Alquoran, and emboldened by the increase of numerical strength, agreed upon a holy war, for the coercion of their heathenish, and as yet unbelieving, neighbours and fellow-countrymen. An opportunity soon presented itself, at a heathenish feast and dance, when one of the Moslem priests tore up the drum of an unbeliever, and the offence thus given to the idolaters was received as an uncalled-for provocation. An endeavour on the part of the heathenish populace to resent the outrage committed on their hereditary practices, was eagerly seized upon by the fanatic Fulbe, who regarded this incident as the propitious moment for entering upon the Jihade, or holy war, against the unbelievers. Thus a crusade began, which extended to the neighbouring tribes, when a number of nationalities, one after the other, were forced to accept the Crescent in exchange for their hereditary and traditional superstitions. The Fulbe, hitherto ruled by Alfas and priests, resolved then to choose a king, to take the supreme command of their armed hosts in their frequent warfare, because, after the Moslem tradition, the wars of the faithful with unbelievers, to the intent of their conversion, is unlawful without a king or supreme head. The royal dignity was then, by a plebiscitum, conferred upon the Alfa of Timbo, an official person who unites the office of magistrate with the authority of a high priest. From henceforth this dignitary assumed the two-fold authority of imaum and king, and possessed the prerogatives of watching over the interests of the faithful in spiritual matters, and of taking the leadership in their politics. The first attempt of the Fulbe to suppress heathenism became successful, and, with the introduction of the doctrine of the Prophet, also the political supremacy of the Futa dynasty over the surrounding territories, became established and finally acknowledged.

The following extract from the official report of the Rev. Edward Blyden, now Minister from the Republic of Liberia, of a journey to Falaba from Sierra Leone in the year 1870, also illustrates the method in which the Mohammedans in North-West Africa extend the influence of their faith:—

The Hooboos, moreover, being Mohammedans, while the people of Falaba are pagans, invoke certain doctrines of their religion, which enjoin war against infidels, to give a sanction or an excuse to deeds which disgrace humanity; and in spite of the efforts of the king of Timbo, to whom they owe allegiance, they are fast developing their occasional and unconnected acts of brigandage into a regular system of pillage and plunder, under the dexterous euphemism of war against the enemies of Islam, by which they enlist on their horrible service recruits from among the zealous Mohammedan youths in their country.

The travels of Dr. Barth, in 1854, afforded him

an opportunity of witnessing the *modus operandi* of the extension of Mohammedan Arab power in the entirely new and untouched countries of Kanem and Adamawa.

At the present time there is a belt of Mohammedan States extending from the confluence of the Kworra and Binue to Wadai; of these we know most of the State of Nupe under its king Umoru, who is tributary to the Sultan of Sokoto. It can hardly be supposed that the sway of these chiefs is exactly that of civilised or civilising powers. In its aspect, as a form of Government, there are all the incidents of an iron despotism intensified by fitful and arbitrary oppression, cruel and ferocious punishment, and frequent military expeditions for the purpose of slave hunting.

Seizure of property without any provocation is recorded by the mission agents, and instances are given of cattle and other property being sent for protection to the mission premises when such raids are anticipated. Mr. Johnson, a missionary of the Church Missionary Society at Lokoja, writes:—

The truth is, that the people long for protection, which, under the present system, they do not enjoy; and they are gradually streugthening themselves in the belief that their safety largely depends upou their making themselves our friends and neighbours.

An interesting and pertinent illustration of this is to be found in the following story. I must premise that the whole of the Nupe country is considered as the personal property of the King, who is himself subject to the Sultan of Gondo. The latter monarch, though politically independent of the Sultan of Sokoto, yet yields him precedence, and offers annual presents to him, as the elder brother. It is the custom to assign districts and provinces as mensal lands for the support of each of the childreu of the Sultans; and these princes appoint officers over their possessions to gather the taxes. Some of the officers are a rapacious set, who grind down the people by exacting nearly as much again as the princes may have chosen to impose. Wherever their highnesses pass, they take away from the inhabitants their hard-earned property; so that their progress through any district very much resembles the ruin caused by a plague of locusts. On such occasions they would never limit themselves to the lands regularly made over to them, but would settle down upon auy that lie in their route, and make the most exorbitant requisitions. Once, news came that a son of one of the Sultans was going to Lokoja, *via* Kipo. The villagers in the neighbourhood were frightened out of their wits. Some left their houses entirely, and weut to stay in the bush until this tyranny was overpast. The majority, however, brought their beds, cooking utensils, cowries, and all their belongings to our Mission-house for safety, and filled the parlour, bedrooms, piazzas, and garret with their worldly good aud chattels. Mr. Paul was away from home, but had left word that the Prince should not be allowed to enter the house, but that his wife was to send him handfuls of kola nuts, the usual token of welcome and goodwill. In due time the Prince came, and Mrs. Paul faithfully observed her husband's directions. He was too polite to take advantage of the absence of the master of the house to force himself in, and so, after gazing about a few minutes, and expressing his admiration of the house, he took his departure. The next thing heard of him was that he had plundered a distant town of all the sheep, fowls, goats, and corn, and compelled the unfortunate inhabitants to provide ever so many bags of cowries.

The same writer adds in "A Journey up the Niger":—

I must now point out one or two dead flies in the ointment, that my account may not seem to have a partial and one-sided appearance. With all his enlightenment, the King has not yet seen that it is for the advantage of his country that the cursed and degrading system of slavery should be abolished; on the contrary, no one seems more earnest in upholding the institution. While in the audience chamber, a poor man who could not pay a debt of 2½ head cowries (5s.) offered instead a little slave boy. The King accepted the exchange with a smile. Himself pointed out to us a white horse for which he gave 10 slaves, and told us that that beauty and another, which I afterwards saw, were attended daily by 50 slave boys! Slaves are a medium of exchange here like cowries. They are offered for sale in the public markets daily. It is nauseating to hear accounts of the miseries which these wretched beings suffer from the cruelties of their owners.

There was another thing which distressed me very much. The former King had a set of cannibals kept in the town, who were used on special occasions as ministers of his vengeance. The present King retains them apparently for the same reason. He told us that at a recent war in which he engaged by the special request of his suzerain of Gondo, he actually caught the King of the enemy with his own hand. On the army returning home, the King gave the unfortunate chief to the head of the cannibals, who with his companious devoured him greedily. We were told that we might see the skull if we would, but none of us showed any curiosity that way. Most sickening are the stories told of the habits of those wretched specimens of humanity—the cannibals. The Turkey buzzards, which are so numerous at Bida, are not more fond of offal and carrion than these human buzzards are of the flesh of incurables. Lepers are not permitted by them to live; like scavengers they would pounce upou them and devour them with gusto! I was told on one occasion they made a journey to Lokoja. No sooner did the news that they were approaching become known than 17 lepers crawled away and effected their escape to the other side of the river, and thus saved themselves from the horror of being killed and eaten. While we were at Egan they got hold of an incurable; we could see them paddling away at a distance, and hear them singing merrily and rejoicing at the prospect of the good feed they were going to have. Why should I coutinue any longer in this strain? There is much to distress the heart of a Christian man when he contemplates the dark deeds which are daily perpetrating in this dark corner of the earth.

Of all loathsome and horrible means of inflicting punishment under circumstances calculated to inspire horror, what could be worse than to employ a band of cannibals to catch and eat offenders. Let us hope this is a form of Mohammedan Government only employed by the Emir of Nupe.

In its civilising effects, Mohammedanism is here, as generally in intertropical Africa, at a very low pitch; where fire and sword are not the instruments of propagating it, the chief means employed are the giving of charms to women, on the understanding that their children thereby become Mohammedans, while the knowledge imparted in the Mohammedan schools is mainly confined to a gabbling over of sentences of the Koran. The following account is given of a Mohammedan school in the Yomba country, by the late Rev. E. Roper:—

The Mohammedans were as ignorant as the heathen Yorubas, They have priests, called alufas. They have schools, also, for training boys as priests, yet they are as ignorant and superstitious as the heathen. One day

I went into a Mohammedan school, and, after a little social chat, I said to the alufa, "May I ask your boys a few questions?"

"Yes; by all means," was the reply.

Each boy had in his hand a square piece of board, and on each board was some writing. Turning to the class, I said, "Boys, what are you writing?"

"Arabaka!" said several. They meant Arabic.

"Will you read what you have been writing, that I may hear?"

They all read together something of this sort—"Burra, Kurra, Burra, Kurra, Allah, Allah!"

This was repeated as rapidly as possible, and for a considerable time; then they stopped.

"Well, boys," I said, "will you now translate for me your Arabic writing into Yoruba or English words, that I may know its meaning?"

"It is Arabaka, white man."

"Yes; but translate the words into Yoruba, your own native language."

"It is from the Koran, Oyibo."

"Very well. Tell me the meaning in English or Yoruba of what you have been writing from the Koran."

"We cannot."

Turning to the teacher, I said, "Do you not teach the boys the meaning of what they write?"

"No, Oyibo; we copy parts of the Koran in Arabic on the pieces of wood."

"But why? Where is the use of copying the Koran if you do not know its meaning?"

"Oh, there is very great use. Don't you understand? We copy the sacred words, and then wash from the board the words copied, and the liquid, in which are the sacred words, is effectual in curing disease, and making the body whole when it is sick."

"Alufa, tell me plainly—do you understand the words yourself?"

"No; but I can copy the words on a leaf, and then stitch them in a leathern cover. These words, when worn round the neck or body, are a certain protection against accident at all times. They will even protect us in war from a gunshot, which would otherwise hurt, and probably kill us."

Happy the man who has learnt to write in the Arabic character any of these mystic phrase; his fortune is at once made as a writer and vendor of charms. An old missionary, who had spent 40 years in Africa, writes as follows:—

I travelled a good deal, and at one time spent some days in Ilorin. Ilorin is under a Mohammedan Government, and Mohammedanism is the only religion professed there. I had opportunities of observing the civilising influence of this religion, if there be any, among the people of Ilorin. Now, as respects houses, household furniture, streets, conduct of the people, mode of Government, habits of social life, safety of person and property, their work in metal, wood, earthenware, and textile fabrics, and such other matters that came under my personal observation, I can truly say I know of no advantage possessed by the people of Ilorin over those of Abbeokuta; but, as regards general honesty and protection of life, the heathen of Abbeokuta are much in advance of the Mohammedan of Ilorin. In one respect, the Mohammedan has an advantage over the heathen, in that they have schools to teach writing in Arabic; but the writing is confined to extracts from the Korau, and used chiefly for making charms, and not for the diffusion of knowledge. Two great evils exist in the Yoruba country; one is the general practice of polygamy, and the other is slavery. These evils are left untouched by the Mohammedan for removal, but he helps the heathen to continue and increase them; his religion allows it. As regards slavery, he enters into the purchase and sale of slaves; the greatest slavetraders are found among them; he will join in slave hunts, and make charms to give themselves or the heathen success in kidnapping or any other act of robbery.

Let us now turn to the Eastern streams of Mohammedan influence, bringing its civilisation into contact with the barbarism of eastern inter-tropical Africa; of the northern, that emanating from Egypt, not much need be said; the story of opening up of the White Nile, in Baker's valiant crusade, and the record of the heroic Gordon's labours and troubles have stamped the branding words, slave trade, on that which might have been, but for them, hereafter euphemistically denominated an extension of Mohammedanism. Further south, and on the eastern coast, we, again, may observe the contact of Mohammedan civilisation with the barbarism of Africa. But here, as on the White Nile, the record of their advance is the story of the slave trade, and the Parliamentary Blue-books, with the despatches and journals of David Livingstone reveal to us the true colours of this advance of Mohammedanism. It is not too much to say, that all the horrors of the East African slave trade so graphically described by David Livingstone, the massacre of Nyangwe, the weary march of manacled men and women for thousands of miles, the helpless victims left to die by the roadside in their yokes and chains, the skeleton-strewn paths, and the crowded slave dhow are but ordinary incidents of the contact of Mohammedan civilisation with, in this case, the harmless, inoffensive barbarism of Africa.

The mention of the East African slave trade naturally introduces the general subject of the slave trade, a feature so frequently recurring in African history as to justify the statement that from the earliest years the contact of civilisation with the barbarism of Africa seems to have been for the purpose of fastening on that land the curse of Ham—"a servant of servants shall he be to his brethren." Portuguese, Arabs, Spanish, French, English, Dutch, and American, all alike have shared in the crime, while, to the honour of our land, it is remembered that she alone undertook the work, and paid the price of freedom to the slave.

We will now pause to consider the results of the contact with inter-tropical Africa, of some of the other powers I have referred to. But as my object is not to describe at length the doings of all nations who have come in contact with Africa, but rather to draw certain conclusions from the experience of such as have had a large share of influence, I propose to consider but two more cases, viz., the action of Egypt in the extension of its sway to the south, and the policy and action of England in connection with her possessions on the West Coast.

The expedition of Sir Samuel Baker, it is well-known, encountered difficulties sufficient to have overawed any one of less herculean frame and dauntless mind. The chief difficulties lay in the vast numbers of hostile savages who had to feel the force of the superior civilisation of Egypt. Baker went forth to suppress the slave trade, to open up steam navigation the equatorial lakes, and to develop the commerce of Central Africa. In two years, to use his own words, "every opposition was overcome, hatred and insubordination yielded to discipline and order, and a paternal government extended its protection through lands hitherto

a field for anarchy and slavery." Yet, some how or other, after his return the slave trade continued, the steamers lay unused at Gondokoro, the commerce of the equator remained a magnificent dream of the future. Then Gordon went to complete Baker's work. The pacification of the equatorial provinces was again undertaken, and the scheme of opening up the great lakes of steam navigation was to be proceeded with. By degrees the country was pacified, military stations in support of one another were carried down to the borders of Aganda. Steamers were placed on the higher waters of the Nile, and the Albert Nyanza was circumnavigated and explored.

Mr. Giegler, the superintendent of the London and Red Sea Telegraphs, writing in September last, states :—

All along the White Nile the blacks have either shown themselves perfectly indifferent to all improvements the Egyptian Government has introduced, such as the erecting of many stations, putting together steamers and iron boats, or they have heartily participated in them. Only a few days since a Syrian engineer returned from Dufli, where he had put one of the steamers together that Sir Samuel Baker brought out, and which is now, I believe, together with a smaller one, on the Albert Nyanza. This engineer tells me that while he worked there with his men (all Arabs and negroes) and with a few soldiers as a guard, hundreds of blacks, from far away districts, came every day, either to look how the men worked or to assist them voluntarily. But although iron and steel of every size and shape was profusely scattered about the station and its vicinity, not a single nail was missed; yet there was a chance for them, as the best tools of every description were there, sheet steel, excellently fitted for lances, &c. I know that travellers who have been up the White Nile will look upon what I say with an incredulous eye; they will recall their own experiences, the vexations they were exposed to in their intercourse with the natives, but they should not forget that since these years have passed, aud to-day the Egyptian Government has a firmer hold on the negro tribes right up to the Albert Lake and M'rooli than six or seven years ago. It would astonish those who knew the White Nile of a former period, to hear that it is by no means a rare thing that a single soldier is sent with a letter from Lado to Dufli, a distance of 85 miles, where a few years ago only a strong armed force could pass.

Yet, notwithstanding all that has been done, I am inclined to believe that, in a little time, we shall hear that all hope of utilising the provinces annexed in Unyoro, or of planting steamers on the Victoria Nyanza, has been abandoned, and we shall see the Egyptian posts withdrawn, and her efforts confined to those parts of Africa more readily accessible from Khartum.

The waste of marsh and lagoon through which the Nile oozes rather than flows, the vast numbers of untouched savages to be controlled, present exactly those obstacles to advance and development in this direction, which must have, 3,000 years ago, confronted any attempt at extension on the part of Egypt, while the produce to be reaped as the result of all this effort is evidently of a character which could not repay the outlay, even were Egypt able to compete for it with the more natural route by the East Coast.

Turning now to the West Coast, I would merely mention, in passing, the French settlements at Senegal and on the Gaboon. These, however, do not, as far as I know, afford any data for my purpose, and I, therefore, pass at once to consider the influence exercised by Great Britain, in her four settlements on the West Coast, the Gambia, Sierra Leone, the Gold Coast, and Lagos. Of these four settlements, two, the Gambia and the Gold Coast, were occupied in 1620 and 1661 by trading companies, and they were maintained chiefly for the promotion of the slave trade by large Parliamentary grants. Lagos was acquired in 1860, with the view of rooting out a notorious slave trade community, while Sierra Leone was commenced in 1791 for the purpose of affording an asylum for liberated slaves, and with a view to the civilisation of the surrounding tribes. Their value as colonies is very small, since the climate of the West Coast will always prevent Europeans from settling there, except to a very limited extent. Their real value to Great Britain consists in the aid they have afforded in the suppression of the slave trade, in promoting native industry and enterprise, and in establishing friendly relations with the surrounding tribes and trading caravans from the interior.

Now, although the action of England in the suppression of the slave trade is not exactly the contact of its civilisation with the barbarism of Africa, it would be impossible, in dealing with my subject, to omit a reference to that which has played so important a part in the history of Africa. Not only is the Englishman respected in those countries which suffered from the trade, but the benefit derived by the restoration of peace and the opportunity for cultivation and sale of the natural products of the country are manifest to all acquainted with the Niger and the Yoruba countries.

In a journey made in 1872 by Bishop Crowther, from Rabbah, on the Niger, through the Yoruba country, he passed along the centre of the region which had been ravaged by the slavers, and visited the very spot where, 50 years before, he had been carried away, a newly-captured slave. He states that, travelling for 25 days, at an average of 15 miles per day, he passed every day through four or five populous villages, or small towns, full of thriving inhabitants, all agriculturists, and, in some districts, engaged in producing palm oil or growing cotton, articles that now form the bulk of the export trade of Lagos. The extent of the commerce carried on at the four settlements I have named may, also, be fairly accepted as indicative of, at any rate, one result which has flowed from the abolition of the slave trade; whether that result is for the real benefit of Africa must depend upon the character of the articles sent by us in exchange. This may fairly be examined into when we pass to consider how far our African settlements have fulfilled our hopes, that they would be centres whence should emanate civilising influence into the barbarism lying around.

I am not able to speak as to the existing results on the adjoining tribes of the Ashantee campaign, or of the present beneficial influence of the Gold Coast settlements. I can, however, form an opinion as to the extent of the influence exercised by the British Government from the two settlements of Sierra Leone and Lagos. As far as the immediate vicinity is concerned, we cannot say much for the beneficial influence of the colony of Sierra Leone. To the north, on the Bullom shore, at eight miles distance from the colony, tribal disputes, going

the length of murder and bloodshed, have occurred not long ago. On the south, in the Sherbro country, the British Commandant nearly lost his life, about two years ago, while endeavouring to reduce some hostile tribes to subjection; while to the east, in what is called the Quiab country, the influence of Sierra Leone does not extend beyond the borders of the colony.

At Lagos, trade and commerce have again recently suffered most serious checks in consequence of the closing of the roads, owing to the quarrels between the Yorubas and the Egbas. Two important cities—Abeokuta and Ibadan—situate one about 70 miles north, and the other about 85 miles north-east of Lagos, are permitted almost to paralyse the trade of an important settlement, which in 1875 imported English produce valued £459,737, and exported African produce worth £517,536, its total for that year being, therefore, £977,273.

The question in dispute being the right of access by the Yorubas to the coast, a tribe still nearer—viz., the Ijebus—took part against the Yorubas, and induced a petty chief in the Lagoon to attack a caravan coming round from Ilorin. All this time there was no interference by our Government. Nay, so hopelessly neutral was its position, that although a British subject was taken prisoner in passing from Lagos to beyond Leckie, which is a dependency of Lagos, the Government made no sign, save to forbid his employers, the Church Missionary Society, from sending up their mission steamer to rescue the man. On this occasion, I am happy to say, the officers of the vessel asserted their independence, and went and rescued the man. Whatever may be the reasons for the line of action pursued, I think it may be stated that the Governmental action has not been successful at these settlements, in the direction of extending civilising influences among the surrounding tribes.

The Government seems, during the last eight years, to have abandoned the position of the protector and guide of the adjoining tribes, and has confined its attention to the mere administration of the settlement. But beyond this attitude of passive unconcern at tribal wars, the policy of the Government has permitted, and is encouraging, the commission of a great wrong to poor Africa. I refer to the enormous importation into West Africa of spirits. During the four years ending 1875, the total approached 7,000,000 gallons, of which Lagos alone received 1,849,921 gallons, at a declared value of 1s. 10d. per gallon, the duty being 6d. per gallon, and the spirit selling in Africa for twenty times its real value.

It is not to be wondered at that, both at Lagos and in the interior, and in the Niger, spirit drinking, with all its fatal consequences, is largely on the increase, and yet the Government professes itself to be powerless, and is so because it occupies these settlements, and does not guard a sufficient adjoining coast-line to render impossible the entrance of spirits and other goods save through our own settlements. Hence, while in the other colonies, such as St. Helena, the Cape, Australia, and Canada, the rate varies from 4s. 2d. to 14s., the African settlements are compelled to reject a rate which would make the imported spirit contribute a handsome sum towards the inadequate revenues of the settlements.

I must confess I view with regret the present aspect of our West African settlements. I should like to see exercised a larger, more generous, and a somewhat paternal line of policy. Especially in the vicinity of Lagos I would advocate an entire coast-line, the firm and decided adjustment of tribal differences, and more responsibility and freedom accorded to the Lagos governor; also the exercise of a more decided control on the Niger river, going as far as the presence of a vice-consul at the confluence.

The review I have thus given seems to show that, on the whole, the contact between civilisation and the barbarism of Africa has, at any rate, under State direction, not been conducive to the spread of a beneficial influence, while the causes appear to have been due sometimes to the low standard of the civilisation of the superior power, sometimes to the operation of those laws which influence the social condition of man, and in our own case to the policy we are apparently compelled to adopt.

Though not exactly within the scope of my subject, a reference may be expected to the three wars in which England has, in the last 10 years, engaged in Africa. Though hardly to be classed under the contact of civilisation with barbarism, it would be supposed that the Abyssinian, Ashantee, and Zulu wars would and will produce results favourable to the introduction of civilisation.

Of the Abyssinian war I need not speak. Its area is not within our limits. For a time the Ashanti campaign bore its fruits, and the terror of the English arm will probably restrain the Ashanti power, but the rapidity of the whole transaction, and its being a mere military expedition, prevented the opportunity of planting any seed of civilisation. Indeed, to have employed the costly machinery of that expedition for any such purpose would, in consequence of the operation of physical laws, have involved so great a sacrifice of life as to have rendered the attempt unjustifiable. But the circumstances of the Zulu war would seem to show that it is not only a swift lesson that has to be taught, but a powerful organisation for mischief which has to be shattered or weakened. Those who are familiar with the story of the massacre of Unkunginglova forty-one years ago, would be inclined to recognise in the wily craft of Cetewayo, and the magnificent fighting power of his people, a danger foreseen by the first English resident in Zululand, who gave it as his opinion that it would be impossible for any civilised power to settle on the Tugela frontier, without incurring the danger of being exterminated by the Zulu, or undertaking the bloody task of vanquishing them.

But notwithstanding the conclusion I am compelled to draw as to the want of success in planting civilisation in Africa under the auspices of the nations I have referred to, it may be asked: "Has no result followed the Exhibition on the borders of Africa of European civilisation?" Man is an imitative animal, and there are many instances within our reach of the desire to copy the habits of the more civilised race. But this mere attempt at imitation is not the reproduction of civilisation. In the colony of Lagos and in the adjoining country, men who have acquired wealth desire nothing so much as to imitate English habits, and as the large and growing trade of that place is by degrees creating the class who have wealth to

spare, we find English luxuries in demand, and English comforts sought after. But if attained, they are not enjoyed by the possessor. I have been told of one man, who built himself an elegant house, furnished after the most approved modern fashion, but yet neither he nor his family inhabited it, but took up their abode in a hovel adjoining. Again, it may be asserted that trade must be the pioneer of civilisation. Plant commercial enterprise in the heart of Africa, and you sow the seeds of true civilisation.

Mr. Buckle has shown that the higher forms of civilisation are not attainable, save where, by a combination of labour and produce, wealth is acquired and distributed among the people themselves, and so distributed that a class is created with leisure to think and teach.

Inter-tropical Africa is so circumstanced, that the wants of the population are easily supplied, and the few who accumulate wealth do so rather by the exercise of power than by the operation of the usual laws. Moreover, the people's wants being but few, they are in reality wealthy, and a great change in their surroundings would be required to induce them to exchange their present form and amount of labour, for the efforts which would be necessary to produce wealth in our sense of the term. Even if, in any one locality, voluntary agency were to teach and instruct the people as to the value of labour, no advance would be made in the creation of capital unless a product was found which could be exchanged for that which, in the eyes of those people, would be wealth.

Almost every great nation of the world contributes to the great central marts, and in large quantities, their staple of produce, and save in the case of land utterly unknown, those products are looked for from certain continents. Until recently, with the exception of a little gold, intertropical Africa supplied the markets of the world with but two products, ivory and slaves, and it is a somewhat singular fact, that the Portuguese missionaries to the kingdom of Congo, two centuries ago, state that nothing would come out of Africa but ivory and slaves. Within the last 35 years the oil products of the West Coast, together with cotton, have begun to play an important part in the European markets. They may be obtained to any amount by a judicious system of trade, and the gradual extension of civilisation on the West Coast, provided other hindrances are removed, may be looked for with tolerable certainty, because of the combination of the two elements of success I have alluded to. But, in connection with this trade, it may easily be perceived that the mere pursuit of commerce does not necessarily tend to the true civilisation of the people. Take an illustration. For years and years the oil rivers in the Delta of the Niger have witnessed the presence of the white man, exchanging English produce for the commodities of the country. The free distribution of spirits has always been resorted to to promote trade, of course with the usual results, and the chief native traders remain heathen sunk in the most degrading superstitions.

King George Pepple, of Bonny, a short time ago, on his return to the throne of his ancestors, was seized by his heathen chiefs and thrown into prison, under circumstances of iniquity, and, on the death of the principal chief, Captain Hart, two canoe loads of idols were destroyed by his infuriated followers, in revenge for their inability to save the chief's life.

On the other hand, there are many educated negroes now on the West Coast of Africa, who do appreciate and enjoy that which we call comfort. Nay, more, they are the centre and support of civilisation, which seems likely to bear fruit. Though fostered by the influence of Government in the African settlements, the civilisation which we find there is almost entirely due to voluntary philanthropic agency on the part of men and women, who have endured the baneful effects of physical laws, which play so marked a part in the conditions of African life. It is also due to the fact that the products of the soil of the vicinity form valuable articles for barter in exchange for English produce, which is appreciated in those countries.

Simple as these two elements or factors may appear to be, I would say that without them there is no hope for the introduction, to any large extent, into inter-tropical Africa of the best forms of civilisation.

As a general conclusion, not only do I think that no large mercantile scheme will prove remunerative in Central Africa, I believe that the success of such a scheme would not tend in the least to promote the civilisation of the people. The experience of the past, and the facts of to-day, lead me to believe that the progress towards civilisation must be very slow, and the first germs of civilisation must be planted by men of science, or the philanthropist, or the Christian missionary, both by precept and example. It is the lives and examples of such men as Livingstone, Speke, and Grant, and of those other travellers and agents of missionary societies, who will be content to exhibit to the negro the quiet endurance, patience and gentleness, and power of restraint, which characterise these men, that will do most towards planting true civilisation amidst the barbarism of Africa. And if these seeds germinate into even the simplest forms of civilisation, it must be because the influence of physical laws is not entirely adverse in those parts to the experiment of the continuance there of the white man.

Those who are watching with deep interest the welfare of Africa, while they view with regret, and must deprecate the high-handed proceedings of some, will welcome, with hopeful anticipation, the patient and self-denying efforts of that band of earnest men who, from Livingstonia on the South to Uganda on the north, and on the east and west of the continent, are seeking to plant the highest and best forms of civilisation amid the barbarism of Africa.

DISCUSSION.

Mr. Christopher Cooke said he had seen, in the *Globe* of that evening, extracts from two letters with respect to the use of elephants in South Africa. He had also lately seen the Sultan of Zanzibar in the museum, and he liked his appearance very much. He thought he had done a great deal to promote civilisation in Africa. Last autumn he also heard a sermon from Mr. Randall, who had been out there, and stated that the mission had done a good deal of good, but had to be given up owing to want of funds.

Rev. J. P. Farler said he was chaplain to Bishop Steere, and it was a mistake to suppose that the mission

had been given up. He was soon going out to Zanzibar again, and at present there were 12 clergymen and 12 laymen at work in the neighbourhood. The funds had greatly increased this year, and there was no deficiency. The Bishop was now engaged in opening up new stations in different parts of the country. They had a printing press at Zanzibar, from which copies of the Bible, Prayer-book, and educational books were constantly going forth, and the whole of the work, both printing and binding, was done by the native Africans.

Sir Charles Shand said he was well acquainted with the Sultan of Zanzibar, having often met him both in public and private, in England; and there was no doubt he was most anxious to do his duty to his people by furthering in every possible way the civilisation tendered to him—chiefly by the hands of England. He could not help thinking that probably we should derive more real fruits, in the first place at least, from the voluntary efforts of able and zealous missionaries than from the operations of ordinary commerce. The problem of civilisation and barbarism coming into contact was a very difficult one. Unfortunately, where there was nothing but ordinary commerce going on, the use of spirituous liquors came into play, and the consequent evils were very great. In Madagascar this was very obvious, where the spirits produced a large revenue in the aggregate, although the duty was but small. There seemed to be a large party here who maintained that it was quite right that commerce should be carried on in any way, and that England must get the benefit of it, even though the result was the demoralisation of a people already barbarous. Nothing, in his view, could be more utterly miserable—not even the scenes witnessed in our own country at the doors of public houses—than to see a people who had no discretion at all, who were really barbarous, subjected to the still greater barbarism caused by the use of intoxicating liquors. He agreed with the lecturer that the Government ought, if possible, to interfere in some way to restrict the sale of spirituous liquors to the barbarians with whom we come into contact, for unless they do so, we shall see many of these tribes disappear much faster than they do under natural causes, and the result must be laid at our door, that we have caused their destruction, instead of civilising them. The whole problem was most difficult. There was an old saying, "If you do not kill them, they will kill you;" and in South Africa we had allowed an immense barbarous power to arise, so physically strong, that now we had to send out large reinforcements to cope with it. Perhaps the better way would have been to have nipped it in the bud years ago, but Government would not incur the expense, owing partly, he believed, to the peace policy which pervaded the whole British Empire, and which, carried to excess, was most destructive. We ought to be ready for an emergency; and if we allowed a vast accumulation of war material in the hands of barbarous races, it was like an accumulation of gunpowder in a neighbour's house, exposing us to the danger of an explosion and ruin. He would not make a political speech, but he thought the traffic in rum should be regulated, if not stopped, as well as the traffic in arms and gunpowder.

Mr. Christopher Mast, as a matter of international justice, wished to ask whether the Portuguese had at any time acted morally worse than other nations? He valued the influence which we at present exercised, and hoped we should extend it over South Africa further than it had gone hitherto; but he did not think it necessary to undervalue the services which other nations had rendered before us, and there was no need to run down the Portgueese, as was now the fashion in this country. If they were no longer what they used to be, it was simply in the order of nature for nations to rise and fall. If the Portuguese introduced slavery, and were rapacious, and their governors became rich, so it was with other nations, and many governors in India had become rich. Then, again, with regard to Mahommedans, the lecturer questioned whether they had exercised any civilising influence; but he had not defined what "civilisation" meant. If it had been laid down that it meant the substitution of law for brute force, order for disorder, and moral law for physical law, there would have been less difficulty in deciding the question. He could easily understand that it was questioned whether the present mode of carrying on civilisation was the highest mode, and whether another method might not now be pursued—whether moral force ought not to be more relied upon and teachers, religious or lay, take the place of soldiers. If it were admitted that the substitution of moral law and order for brute force was the main characteristic of civilisation, then it must be admitted that the Mohammedans—even though their religion was inferior to Christianity—had done some good. The main difference between Mahommedanism and Christianity, with regard to civilisation, was this: The Mahommedans acknowledged the sword to be the main means, and acted in many ways more humanely than Christians; whilst Christians said it was the law of love which ought to prevail. In regard to teaching, it would not be difficult to point to schools in Christian countries where children were not much better taught than in Mohammedan lands.

Mr. William Botly remarked that the sword, commerce, and missionary enterprise had been referred to as the chief means of civilisation. It seemed to him that if commerce generally were conducted in a more straightforward manner, it would do a great deal more than it had done. If the sword were used in self-defence rather than as an aggressive force, it would have a better effect, and when you came to the religious and missionary part of the question, he could not help noticing that dogmas of the Church of England, or any particular creed, were put forward too prominently to these people, who could not understand them, and that if the preachers of the Gospel would follow more the steps of the Founder of their religion, and offer a great practical example of morality instead of these dogmas and creeds, which were really not essential, it would have a better effect. With regard to drunkenness, it was lamentable that a Christian country should go forth to civilise, and combine its religion with traffic in intoxicating liquors. He thought in this respect we ought to reform ourselves before attempting to reform others.

Dr. Mann said he gleaned from the paper that Mr. Hutchinson's chief hope for the success of the cause which they all knew he had at heart, was in the slow and gradual progress of the good influences which were brought to bear in the contact between civilisation and barbarism. He himself had had some experience in this matter, and had again and again been surprised beyond measure to see how very little apparent progress was made from year to year; but if the comparison was made at sufficiently long intervals, it became apparent how large was the gain. For instance, in the particular instance which was now coming before our minds with such vivid and painful interest, our struggle with the barbarism of the Zululand, we had only to look at the natives of Natal and of Zululand, the two being the same race, and only separated by a small river, to see what was the difference between the land where civilisation was in contact with barbarism and the land where it was not. In recent newspaper reports there had been allusion to a body of native volunteers who had been fighting under English officers against Cetywayo. These natives came from a place called Edendale, which he knew very well; it was about six or eight miles from Pietermaritzburg, and he was himself one of the trustees of the land which these held. That settlement was originally formed by a missionary named Allison, who came down from the higher

parts of the colony with a number of wild natives, most of them actual Zulus. They settled down there, and formed what was known as the Edendalo Mission Station. At present, there were 70 of these men fighting as quasi-volunteers, being organised into a part of the native contingent, and it was recently stated by a newspaper correspondent, that, even on the border of Zululand these men commence their daily drill by meeting for prayer. In that station may be seen the people living in houses like Europeans, with furniture in them and gardens round them, each man having but one wife. They have a school and a stone ehurch, built by the men themselves. That showed what was possible with the Zulu race. But there were about 300,000 of identically the same race within the frontiers of Natal, who were living just in the same way as the wild Zulus on the other side of the border, having been for close on half a century in eontact with English civilisation, and yet not having even a bed to lie on, a chair to sit on, a table, or a domestic implement of any kind. Regarding these men and their mode of life, it would seem impossible for civilisation to make way in contact with barbarism, but when you went a little father, and looked at Edendale, it was found that something could be done. At the present time, in Natal, we were coming to a problem of enormous interest. There was a place where civilisation and barbarism had been brought into close contact, so that one must influence the other. There was no doubt of the great ability and power of the Zulu race, but there was no doubt either of Sir Bartle Frere's statement, that in the state in which they existed, apart from the influence of civilising neighbours, they were nothing more than an enormous man-slaying machine. Yet there was no doubt that the people existing in the wild Zululand had the same characteristics as the natives of Natal. He had been unarmed amongst them for weeks at a time, without the smallest fear of any kind. The Natal natives were identically the same with the men who, in Zululand, were now coming out in the form of fierce, blood-thirsty, cruel savages, having no mercy, no pity, no idea of anything but executing the orders of their chiefs. The whole cause of the difference was simply in the influence of these chiefs. It would be seen now, whatever happened, that the power of Zulu despotism must crumble before the influence of civilisation before any real progress in that country could be made. He had been very pleased to hear the few words from the Chairman, recognising the difficulties Sir Bartle Frere had to contend with, and the character of the work he had to do. As a matter of fact, there was not a man more inclined to feel to the bottom of his heart an interest in the progress of the native races he came in contact with. The course he had taken in Natal had assuredly been forced upon him by the deliberately attained conviction that until the power of the chiefs was broken, no progress could be made with the Zulus.

The Chairman, in proposing a vote of thanks to Mr. Hutchinson for his very able paper, said he should be sorry if it were supposed that in anything he had said he intended to contrast the conduct of the Portuguese with that of the English. The Portuguese, like the English, were concerned, unfortunately, in the slave trade with Africa, a discredit which they shared with England and many other nations. As had been said, if we wanted to know what progress had been made in civilisation in dealing with barbarous races, we must not compare this year with last, or perhaps not even with the last century, but must go back two or three centuries, and see what had been the result in the course of time of the efforts made by European countries in the cause of civilisation. One of the great difficulties we had to encounter in our conflict with the Zulus had been the importation of arms into Delagoa Bay, and he was very glad to find that the Portuguese Governor had done his best to prevent this traffic going on. It was much to be desired that we could put a stop altogether to the practices of these gun-runners who supplied the natives with weapons and ammunition. A very appropriate remark had been made about the importation of spirits. He remembered yoars ago, sceing what happened in North America; when the English Government and that of the United States sent presents to the natives, the same ship always brought rum and whiskey, and the blankets and clothing were soon swapped for spirits, so that in the end, more harm than good was done by the philanthropy of the British Government. A striking instanee of the evil had been seen reeently, when Cetywayo excused himself for having sent an insolent message to Sir Bartle Frere, on the ground that he was under the influenec of rum at the time, and some of his admirers in the House of Commons seemed to think this was a good excuse, though it would not be admitted for a moment in an English Court of Justiee. No doubt one of the great causes of the destruction of the North American Indians was the use of spirits. No doubt there was a tendency on the part of native races to disappear before the white man; it was a fact whieh they all deplored, but we ought to consider seriously what it meant, and ask ourselves whether they perished by the vices of civilisation, or so to speak, by the act of God. He believed it was in a great measure by the evil influences brought to bear on them by those who ought to be their civilisers and protectors, and that by the poison of that corrupt civilisation, their ruin was too often affected. There was too often in India and elsewhere, a contemptuous tone adopted towards the natives which was much to be regretted. He remembered, some time ago, in a despatch from a late Governor of the Cape, a sentenee expressing his astonishment at what he called the incredible waste of Providence in bestowing such magnificent cattle on such miserable people, and that was, unhappily, the spirit in which too much of the writing and speaking with regard to these people were conducted. There was no doubt that the Dutch system was to make expeditions to lift the cattle from a native kraal, which naturally led to reprisals, and the consequence was that, in the course of the present century, we had had, at least, seven Kaffir wars. He must say that, though he quite agreed with defending the colonists against danger, still, we ought to encourage them to be more self-reliant and more circumspect in their dealings with the native races around them; because it was not very satisfactory that England should have to pay the piper for all these rather expensive undertakings going on in distant lands. It was to be deplored that this spirit had not been more cultivated, as it had been, happily, in New Zealand. We had not had a Maori war now for ten years, and he doubted if we should ever have another; simply because the colonists had learned more prudence. The arguments that evening had rather been that we should rely on other agencies than those of commerce. Of course, being a commercial country, we must assume that the oourso of our trade would lead us all over the world; but it would be a great mistake to suppose that either our trade, or our arms, alone would enable us to civilise mankind. Some time ago, we were warned by an American writer to look at the ancient monarchies and the republics of the Middle Ages, and the other extinct empires of the world, and that we must not assume that an empire could be founded on the shifting sands of commercial interchange, or that a nation would prosper whose battalions were marching under a banner fanned by the terrible wind of war. Thero was one power only which could breathe life into the ribs of death, and which was the only potent agent in civilisation—the power of real, true, practical Christianity.

The vote of thanks having been passed,

Mr. Hutchinson, in reply, said the problem dealt with was not the extermination of races, though he believed Mr. Trollope was right in thinking that

in Africa the black man would always preponderate over the white. The question he had set himself was why did this great continent, having been subjected to the influence of Mohammedanism, of the Portuguese, and, to some extent, of the English, still present the appearance of the dark continent. He had dealt the same justice to England as to Portugal, and in some respects our own country was even more to blame. The question was, why was the continent still so dark? To give a familar illustration. When you had a child vaccinated, the success of the result depended first on the character of the virus, and, next, on the circumstances of the patient. They admitted there was a certain degree of civilisation in Egypt; why had not that made itself more felt? First, there were physical obstacles and the circumstances of Egypt. Then, dealing with Mohammedanism, without going deeply into the subject, he said that its civilisation had not that strength or adaptability in itself which made it germinate and grow in the nations with which it came in contact. By civilisation he meant that which elevated and improved the condition of the people by the gradual action of its own laws; and he did not find that that prevailed in Africa. Coming back again to Portugal, he had only stated historical facts, which were to be found in its own records. The remarks he wished to have made with regard to England's connection with the slave trade on the East Coast would have brought out what he most sincerely held, that influenced by our pressure and influence, the Sultan of Zanzibar was doing a great work in Africa. He had most honestly and faithfully fallen in with our wishes, and there was no doubt he had been immensely improved by his contact with English civilisation. With regard to the introduction of elephants, an expedition was now on its way to convey a number to Zanzibar. He had received a letter from Dr. Kirk, who said it was evident the question of elephants was coming to the front, but he would not advise his society to incur the expense of procuring them at present. In his opinion, it was not by any great scheme for employing £10,000,000 of capital, suddenly plunged into the middle of Africa, that civilisation was to be secured, but by the individual efforts of devoted men and women who would give themselves to the work. He did not argue against commerce, but his experience taught him that commerce alone would not obtain the results required, because men engaged in trade had not the requisite time to spare; the merchant had his business to attend to, and he could not go about improving the moral condition and raising the social status of those who brought him the various products which he bought. He, therefore, came to this conclusion, which was confirmed by the experience of his society in other parts of the world, that if civilisation in Africa was to come, it must come by the gradual slow process of practical education in some form or the other, and as subject to the difficulties there were very much greater owing to the peculiarities of the climate, the process must be a very slow one; and it was only by appealing to the highest principles that they could expect to get men and women to devote themselves to the humble task of gradually raising up the sons of Africa to receive the benefits of the highest forms of civilisation.

ADJOURNED ORDINARY MEETING.

Tuesday, June 10th, 1879; A. H. Brown, M.P., Vice-President of the Society, in the chair.

The discussion on Mr. Lloyd Wise's paper, on "The Government Patent Bill," adjourned from the 20th May, was resumed.

Mr. W. Smartt said he was anxious, if possible, to convince the meeting of two things, first, that the amount at present collected by the Government was greater than was intended by the promoters of the Act of 1852; and, secondly, that were the total amount now collected reduced from £175 for a 14 years' patent to £37 10s. for a 21 years' patent, the total receipts of the Government would be much greater than at present. Clause 44 of the Act of 1852, divided the fees intended for meeting the expenses of the Patent-office from the stamp duties intended for the use of the Treasury; and the Commissioners' "Journal," of 11th October, 1878, page 987, gave the receipts for patents at £168,197, and then added "including revenue stamp duties," showing that they were two separate amounts, amounting to £31,640. During the ten years immediately preceding the passing of the 1852 Act, the average number of patents was only 468, and the framers of that Act, who probably did not expect an increase in the average for the years 1853 to 1862 to 3,103, evidently decided upon the present high charges with the expectation that they would be about sufficient to cover the expected expenses of the Patent-office, and to leave a definite proportion for the use of the Treasury. Had the number of patents continued as before the passing of the 1852 Act, the total receipts would have been about £15,725, of which the "revenue stamp duties" would have taken £2,995, and there would have remained £12,730 to cover Patent-office and other expenses. He called attention to these facts, to show that it was only intended by the 1852 Act to raise a comparatively small and separate sum for the use of the Government, and beyond this, to raise no more than would be ample to cover the various expenses in connection with the patenting department. The enormous increase in the annual number of patents, from 468 to 3,103, and of the receipts, from £15,700 to over £150,000, was, no doubt, not expected, or, perhaps, thought of. It appeared there had been neglect on the part of past Commissioners, in not submitting to Parliament, in an annual report, a suggestion that the charges should be so reduced as to simply cover the duties and the expenses of the Patent-office; and, to use the words of Mr. Whitaker, "It requires a keen eye to analyse any Government return, even on the part of those initiated in the perusal of Blue-books." In the Commissioners' "Journal," the salaries of the Patent-office were separated from those of the designs, registry, and other departments; but various sums belonging to the several departments, amounting to nearly half the total expenses, and including the enormous sum of £16,885 for paper, printing, &c., was so bulked as to render it impossible to determine, by the said "Journal," the actual cost of the branch for patents. However, this year's Civil Service estimate gave, as the estimated expense of the patent department, £27,175, and adding to this the revenue stamp duties for 1877 of £31,640, they had a total of £58,815, as about the sum which the 1852 Act intended should be paid for the present number of patents. This would give an average of about £12 which should be paid for patents, as against the £34, or thereabouts, which was paid at present, and it suggested that an immediate reduction of all the patent charges of about 65 per cent. would only be honest treatment for inventors, and in agreement with the spirit of the 1852 Act; but whether the Government agreed to this argument or suggestion or not, any reduction of charges, and improvement in the system, would result in a proportionate increase in the number of patents. The average annual number of patents under the 1852 Act had been about 3,600, or about 10 times the average of the previous 25 years, which was 337 only, and a proportionate increase might be again expected if the charges were sufficiently reduced. The number of applications under the low prices of the United States was about 20,000, but this number should be exceeded in England, because of the better

facilities for "communications" from the Continent. There were many inventions that could not be safely covered by one patent, and which would not compensate for taking several patents at the present high charges, and he felt certain that such inventions would take a very large number of patents, were the charges reduced to a reasonable amount. Many inventions gave a manufacturers' profit not exceeding one penny each article; the Government and agents' charges alone payable the first three years, absorbing the patentee's profits on over 24,000 such articles, without leaving any amount for advertising or a net profit. Were the Government total charges reduced to £2 10s. for the first year, £5 the fifth year, £10 the tenth year, and £20 for the fifteenth year, the number of applications for patents would probably considerably exceed 20,000, and the receipts might be expected to considerably exceed £50,000 for each year, which would be sufficient to cover the additional expense for increased office room, and the salaries of officers, besides leaving the Government as much as they at present received. He begged leave to suggest that these should be the only charges for granting patents, except when "objections" were lodged, or amendments or difficulties occurred, when the necessary additional charges should be collected. The adoption of this scale might render it necessary to obtain much larger premises, for the erection or obtaining of which a part of the accumulated income of the Patent-office might very well be used; the scale would probably cover all over the office and other expenses, and give the Government more surplus revenue than was obtained at present, and considerably more than was intended by the Act of 1852, but the reduction would satisfy inventors, who would not then object to the Government retaining any balance remaining after payment of office and other expenses. He thought that, after a few years' working, the Commissioners should from time to time hand Government their opinion as to the advisability of any further reduction. With regard to obstructive and unworked patents, licenses, &c., he considered there should be prepared a simple but adequate form of declaration, a copy of which should be required to be signed by the owner of each patent during the fifth, tenth, and fifteenth years, when, instead of during the third, seventh, and twelfth years, the three payments should be made, and such a declaration could be made an ample check to inventors in respect to obstructive patents and other matters. This declaration should show whether an invention had paid all expenses to the fifth, tenth, and fifteenth years; and it was a question whether a patent that paid by the fifth year, or that was granted to other than the inventor himself, should not die in the fifteenth year. In the event of duplicate applications, and of a subsequent applicant passing the stage of a previous applicant, the law officers should consider the question of fraud or sharp practice, and reject the fraudulent application, if any; but if there be no fraud, and if the applicants could not be induced to make a private arrangement, duplicate patents should be granted at the proposed reduced charges with equal rights, and there should be added on each such patent "duplicate patent, equal rights with patent number so and so." With regard to Commissioners, he thought the Commissioners' "Journal" contained ample evidence that additional Commissioners should be appointed; and the sending of three complete sets of works to Melbourne, Victoria, at a cost of considerably over £10,000, appeared to him an excessive liberality. The same might be said with respect to sending abridgments of specifications to small or contiguous places, and, altogether, the accounts appeared to be in an unsatisfactory form. Any additional Commissioners should act as directors only, and should meet at stated times, to decide upon the general arrangements, but should have nothing to do with the applications for the patents or with specifications; these, for privacy, should be allowed in as few hands as possible.

Admiral Selwyn said:—I have resorted to the method, which is quite unusual for me, of writing down what I have to say, in order to economise time as much as possible. I have asked for a more extended hearing on the subject of the Patent-law Reform, because I hope to bring evidence that mistaken views of the case have hitherto prevailed in the minds of many of those who proposed legislative changes. This subject is either a very small one, affecting only the interests of the small class of inventors, *versus* the somewhat larger class of manufacturers; or it is immeasurably important, as affecting all consumers and all producers over the whole world. It is either the question of the whole progress and well-being of the civilised man; his industry, his trade, his commerce, and his wealth, or it is one not worth an hour's consideration. I maintain that it is the former, and that it is because it has been mistaken by legislators for a small question, that their efforts at amelioration of the laws affecting it have been so often unsatisfactory, and is seldom spontaneous. I appeal to all history to show that the wealth of nations has been more influenced by inventive genius than by any other factor whatever. Such has specially been the case in our own country, and is now pre-eminently the case in the United States, which, to take only one instance, could never have utilised its vast wealth in land without the aid of agricultural machinery. Two influential deputations have wasted their strength in asking for immediate legislation of an unsatisfactory character, which any inquiry into the state of business before the House of Commons this session might have satisfied them was entirely impossible. In the present state of mind of the Attorney-General, shown by the provisions of the Bills, as well as by his remarks on the necessity of saving the public and the public purse from damage, no satisfactory legislation can be expected. Any introducer of a Bill for this purpose must first be convinced on the following points:—First, that a large increase in industry, trade, and commerce would necessarily occur were property in inventions cheaply acquired and efficiently protected; second, that so far from the returns to the public treasury being lessened, those returns would be enormously increased. We have only to prove these two points, and all minor difficulties would, I am persuaded, at once disappear. Is there anyone who seriously doubts that inventions create new industries? Is there anyone who denies that, were patents obtainable at moderate cost, many more would be taken; or that if patent property were better protected, much more capital would be forthcoming to make it the foundation of large industries, profitable trade, and extensive commerce? If there be such, I refer them to history. For the second point, it is not difficult to see that, apart from the question of fees, a development of industry would amply repay the surrender of all idea of direct revenue from such a source. A finance minister might as well rely on a tax upon seed corn, instead of the tithes of the crop, as to rely on patent fees rather than the developed industries of which they are the roots. But, even as to the results in fees, the example of the United States is an encouraging one, of which the figures have often been stated in this Society. I spoke of the minor questions being easily settled, and as regards that vexed question of compulsory working and compulsory licenses, it becomes absolutely simple directly it is approached from the side of the public interest alone. Cases rarely arise where any interference with patent property is really necessary, but when it is proved that the need exists, let a special act of the legislature intervene, and let us not make all property in patents uncertain by introducing special clauses contemplating the frequency of such cases, which has yet to be proved. Some, again, would deny the necessity of provisional protection. As well might one deny to a cultivator the right to a fence round his corn, and say that when he could show a crop would be time enough for such protection. The whole animus of the present

Bill is a grudging recognition of some sort of right to an invention, and a plentiful provision of means for taking it away. Its basis seems to be that of the Communistic idea "La propriété, c'ést le vol." If it must be given, at least it shall be heavily paid for and readily robbed. I have no doubt that any legislator who held the view that a patent was a sort of monopoly, in violation of public rights, would be justified in drawing just such a Bill, and we can expect none better so long as such ideas are in the ascendant. What I labour to prove is, that these ideas are entirely wrong and without foundation, and that a fresh departure must be made if we would have beneficial legislation, or if we would not see other nations step in to deprive us of the fruits of well instructed industry. It is scarcely necessary to say, in this Society, that if invention be the mainspring of iudustry, trade, and commerce, it is the very origin and life of arts, of whatever kind; and if to have faithfully studied these softens manners and deprives man of his brutality, surely that is an additional reason why, in this hall, the members of the Society of Arts should unite in recommending any action that will improve the Arts that may be studied, Lastly, it is, to my mind, absolutely certain that, other things being equal, that nation will have the greatest prosperity which is most solicitous to ascertain and secure, to foster and protect, the property of iuventors and, inferentially, capitalists in inventions.

Mr. Newton Wilson said since he had been in the room he had asked himself from what light they were to regard the Patent-law Bill, No. 2—as a measure to become law, or probably to become law, and as a measure which they should assist in carrying out, or oppose. He took it for granted that it was possible to carry the measure ; and another thing which he should like to take for granted was, that it was probable some such measure might be carried, though he doubted whether he might go so far, because it was possible that a dissolution of Parliament would take place before the present or any similar Bill could be converted into law. They were to look at the Bill with a view to exclude from it any clauses that might be considered directly prejudicial to the rights of inventors, and should endeavour to introduce clauses favourable to inventors. He regretted to observe that all idea of preliminary examination had passed away from the minds of the framers of the Bill, and that the condition introduced in former Bills had been omitted from the present, because it was of great advautage to have an examination of specifications for inventors, not with any view of giving the Commissioners a right to refuse a patent, but rather to give an advantage to inventors, and having what they might consider to be a certified patent as distinguished from one which might simply be passed as uncertified, that is to say, the Commissioners might see objections to it which they consider fatal, and decline to certify that, *prima facie*, it was a good patent. On the other hand they might leave inventors to submit their patents for examination, and be able to give a certificate of having passed such an examination, which would be of great value to inventors. With regard to the scale of fees, after the completiou of a patent, he thought there should be a continuous payment of £5 during the term of the patent, and, to avoid unnecessary inconvenience, the patent should be presented at any stamp office in the United Kingdom, and there receive an impressed stamp for the amount, on payment of a small sum for registratiou. Such an arrangement as that would greatly benefit inventors. He was sorry to differ from Admiral Selwyn on the point of licenses, but he could not understand why the granting of a patent should raise a sort of legal barrier to further invention ; and he rather thought it should be an announcement to the public that a new thing had been introduced, and that, upon reasonable terms, the uso of it might be obtained. Time should be allowed for the development of a patent into such a stage that its true value could be assessed, and three years he considered would be sufficient for the purpose. He feared it would be waste of breath on their part to argue against the provision for compulsory licenses, as that condition had been inserted in all the previous Bills, in addition to which it had been admitted by a deputation that waited upon the Lord Chancellor two years ago, on the subject of the Patent Bill, that they could not seriously object to such a provision. Had there been in the Act of 1852 a compulsory license clause, the English manufacturers of sewing machines of the present day would have held a totally different position in the nations of the world than they now did, and would not have been kept in continual litigation for the last 14 years, as they had been. The first patent taken out in England for sewing machines, by W. Thomas, was unworkable in itself, and absolutely useless, except by the introduction of subsequent invention. Again, he might refer to the case of the patent for skates. Something like 200 patents were taken out for improvements in skates; but, in consequence of the absence of a compulsory license clause, the whole of the money spent in the development of those inventions was sacrificed. He held a good many patents, and, having always granted licenses, he found the plan to work satisfactory. In a previous Patent Bill, a clause was introduced for the extension of old patents, to make them contemporaneous with those under the new law ; but that was omitted from the proposed Bill, and he hoped that, if it ever got into committee, such a clause would be inserted. In conclusion, he would say that, if the Patent Bill was carried, it would be a feather iu the cap of the Government, and inventors for some time might rest and be thankful.

Mr. H. T. Ward said anyoue who has had anything to do with patents must admit that Commissioners who are to do any real honest work must be paid for it. Unpaid Commissioners have been tried and have been found wanting. Able men, like Lord Penzance, willing to work for nothing more substantial than honour, are met with but rarely. The Bill itself was so open and indefinite on many points, that far too much was left to the Commissioners, who have the power to do almost anything not expressly contrary to the Bill. They could almost make a new Patent-law, and may make such demands and impose such restrictions on the patentee as to make a patent unobtainable, or not worth obtaining. If by chance such men as the late member for Leith, or Mr. Coryton, became Commissioners of Patents, glorying as they did in the state of chaos which they say this Bill will produce, as tending to lead to the abolition of patents, what a dangerous power they would have. Such power should not be left to fall, perchance, into the hands of men (apparently irremovable) who stigmatise a patentee as full of audacity, but devoid of merit; and yet themselves have the hardihood to make the non-provable assertion that no man is 14 years a-head of his fellows, and this in the face of all history—of, for iustance, Watt (whose engine has not been surpassed to this day), and of mauy inventors, the value of whose inventions had only been recognised years after their death. If there were to be examiners (as he hoped there would be), let the Bill say so, and define their duties ; these should be to help both the inventor and the public, whose interests are not really antagonistic, but not to prevent the former taking out a patent at his own risk (as at present), provided ho incorporated in his specification all the examiner could fairly require. Only those who had searched for weeks at the Patent-office could have any idea of the difficulty—he might say impossibility—of finding out what has really been done before; and he firmly believed that it was owing to this difficulty, and to the consequent patenting of things partly anticipated, that the Patent-laws had been brought into such discredit. It would be a great boon if they could but get

an exhaustive subject-matter index (always prepared on the same plan, and not differing in different years, like the present ones), and an abridgment in classes, with an illustration of every invention, as in the *United States Gazette*, but with letters of reference, and an abridged description, like the English abridgments prior to 1867, plus copies of the claims. He could not agree with the author of the paper as to the proposed 12 months' provisional protection. Six months was as much as he thought the inventor could fairly claim, seeing that others might blindly patent the same thing during this period, and manufacturers might have embarked much capital in a manufacture which they found nine or twelve months afterwards was patented. If a patent be granted, the sooner the public knew what it was for, the better. It would be a hardship to grant a monopoly to patent agents, as suggested by the author in the concluding paragraph of his paper—even in law a man is allowed to defend himself in person—aud so ought an inventor to be at liberty to take out his own patent if he feels able, without adding materially to the expense by patent agents' fees. Probably the author did not intend to say that a patentee should not take out his own patent, but that others not patent agents should not be allowed to take it out for him. He failed to see how this would work in practice, as, so long as a patentee deposited his own specification, how was one to tell who drew it?

Mr. Hugh Clements said, being connected with a technical association in the City, he came into contact with a large number of working men, and had gathered as their opinion that the Patent-law, as it now stood, prevented artisans from taking out patents. It must be obvious to everyone, that artisans and other operators, engaged in different manual operations, who were connected with machinery, and could see its defects, were the most likely persons to invent some improvement; but how could they do so when a patent in this country, for 21 years, cost over £250? If they sold the patent to a capitalist, it generally led to trouble and difficulty, and the patentee got next to nothing for the pains he had taken in the matter. He did not see why the fees should not be reduced as low as those of the United States, and if that were done the number of patents taken out would be greatly increased. At the present time 3,000 were taken out yearly, being one in 10,000 of the population; but if the fees were reduced there was no reason why one in 3,000 should not be taken out, and more money would be received by the Crown yearly than was done at the present time. The effect would be just the same as when the penny postage was introduced—the lower the charge the more money obtained. He saw no reason why there should be any litigation as to patents, except that the lawyers who drew up the Patent Bills seemed to leave loopholes, on purpose that they might have an opportunity afterwards for displaying their ability, and, of course, to receive a fee for so doing. If a dozen or twenty competent scientific men, who had made patents their study, were chosen by the Government to decide upon patents, they would soon say whether the invention was novel and likely to be useful, and the decision of this body should be final; anyone encroaching upon it should be liable to a certain amount of costs without any expense at all to the patentee. If such a body were appointed, litigation would cease, and a much greater number of patents would be taken out, especially by artisans. Of the patents now taken out, only three per cent were useful, which arose from the fact that those taking them out were not actually engaged in manual labour; 60 useful patents were taken out annually that paid moderately, and 20 that paid very well. The present Bill provided that a patent might be refused after being made public, but he did not think it would be made public until the patent had been actually obtained; for to make it public and then afterwards refuse it was certainly injurious to the patent.

Mr. F. H. Varley, in agreeing with the remarks of the last speaker with regard to a reduction in patent fees, thought that a great impetus would thereby be given to the production of inventions of commercial utility to the country, by persons actively engaged in the working of machinery, who would probably invent, among other contrivances, useful tools and appliances for the workshop if facilities were afforded them for taking out patents, and the present difficulties lessened. The Patent-law Amendment Act of 1852 he considered a much more perfect piece of legislation than the Bill now proposed, and he would, in preference to the latter, strongly support the measure advocated by Mr. Anderson and others, which simply proposed to extend the period of duration of patents to 21 years, with a general reduction of fees throughout. With regard to the reduction, it would be necessary to begin with the thin end of the wedge, and the Government would soon find that a reduction of half in the cost of taking out patents would result in a three-fold increase of their number, and in the revenue from the progressive stamp duties. He had great doubts about the advisability of the proposition for the appointment of examiners, and thought that inventions might very well be left to rest on the responsibility of the patentees and their advisers, the patent agents. How were examiners to be appointed for novel inventions? Had the telephone came first before a board of examiners, they would probably have objected to it, on the ground that even the ordinary Morse signals could not be conveyed by it, and the invention would possibly have been condemned as useless, whereas electricians had been astonished at the remarkable facility with which waves of small amplitude could be sent through the instrument, articulating waves of the smallest current in the telephone being now an established fact. Mr. Bramwell had pointed out the difficulties in the way of examiners in his humorous illustration of the discouragement such a body would probably have given to Watt himself, who, he said, would certainly have failed in getting a patent on their report. Mr. Bramwell, in fact, had very cogently shown how difficult would be the position of examiners, on account of the innumerable subjects which were embraced by the patents taken out every year, not only in all varieties of chemical and mechanical processes, but even relating to articles of dress and jewellery. It would not be possible to appoint examiners for subjects so diverse, and not only so, but there would be the additional difficulty that it would be necessary to appoint some one to examine the examiners. Their duties would require familiarity with every language, and a thorough knowledge of every branch of science and industry touched by the inventions brought before them, and besides being competent mechanicians, electricians, and engineers, they would have to be practical milliners and dressmakers too. The whole proposition was so thoroughly unworkable that it might well be dropped out of the present Bill. With regard to the suggested formation of a Society of Patent Agents, he thought that matter rested with the patent agents themselves. The Inns of Court imposed their own qualifications for members of their own profession, and if the patent agents chose to form a society for themselves, they would, when they became strong enough, no doubt, acquire a title to enforce their own regulations, and might call themselves patent solicitors, or any other name they chose; but they ought not to seek to prevent patentees from taking out their own patents. He would like to see a better system of record and abridgment of specifications in the Patent-office, and if the system were continued as it was in force two or three years ago, it would greatly assist inventors to a knowledge of the rocks before them.

The Chairman said that it seemed impossible to look

for a really working Patent-law reform without the appointment, in addition to the law officers, of properly qualified paid Commissioners. That really lay at the bottom of the whole subject. They did not require men for the office specially trained in every branch of science, and men could easily be found possessing general scientific knowledge to act in that capacity, and to undertake the duties now left for performance by the law officers of the Crown, who could hardly, from their own multifarious duties, be expected to find time to perform others. There should be a properly constituted Patent-office, headed by men qualified in the law and in ordinary general scientific attainments. He was not at all sure that the Bill really contemplated an examination of patents; and one of the great objections to it was that they were dealing with a skeleton, which might be filled in in different ways of the matter. The proposed practice was so subjected to any rules the Commissioners might make, that it was impossible to say whether there was any examination intended before patents were granted. Another question was, the opposition on closed or open documents; and having heard the paper, and the remarks upon it, he was inclined to agree with Mr. Lloyd Wise that, though both aspects of the question presented difficulties, the balance was in favour of opposition on closed documents being the best course to adopt. Patents could always be revoked or upset by legal proceedings, and he was, therefore, decidedly against the clause in the Bill which would throw specifications open to the public for opposition. He considered that the extension of patents to 21 years was not beyond what patentees might fairly ask; and while saying that, he agreed in general with the principle enunciated by most of the speakers, that the interests of patentees were, on the whole, identical with those of the public, and that it was necessary that facilities should be granted to patentees for taking out patents for inventions, which would be of service to the nation at large. He must, therefore, entirely differ from the opinions expressed by Mr. Coryton and Mr. MacFie, considering, as he did, that it should be the object of the Patent-law to encourage inventors by a reduction of the fees. On the question of compulsory licenses he thought that, provided means could be adopted by which inventors could be sufficiently rewarded for their time and labour, there would be nothing wrong in them, but the question how the value of inventions was to be tested, was surrounded with very considerable difficulty. The machinery proposed by the Bill was not sufficient, and might result in injustice to patentees, unless patents were granted for a longer term, namely, for 21 instead of 14 years. The primary question in any Patent-law was that of the stamp duty, and the satisfactory arrangement of the question would give inventors the means of bringing forward inventions which would benefit the commerce and manufactures of the country. He could not see why gentlemen engaged on inventions for warlike and other purposes taken up by the State, should be in a worse position than other inventors, and he had, therefore, been pleased to find that the Bill contained a clause for giving compensation to those who produced inventions for the use of the Crown. Still, a careful examination of the clause showed that the machinery provided for the purpose was unsatisfactory. The payment to the patentee in such cases should not be left to be settled by the Treasury, who were the purchasers, and that proposal should certainly be amended before the Bill became law. No better machinery could, probably, be provided for the purpose than the appointment of arbitrators by the Crown and the patentee respectively, to decide in conjunction with an umpire to be selected by the arbitrators. With regard to imported inventions, he could not see why those made abroad and at home should not be treated alike; there was no reason for any distinction between them, or why the cessation of patents in England should be made co-equal with their expiration abroad. It was only reasonable that an inventor, bringing his invention to this country, should have the full benefit of his patent, and, therefore, the 24th clause in the Bill should be amended, or struck out altogether. Discussion had been raised as to whether or not it was intended that paid Commissioners should be appointed, but there could be no doubt that, if any were to be appointed at all, they would be unpaid, there being no provision for paying them, as the clause referring to salaries only applied to those of the officers and clerks appointed by the Commissioners, and not to themselves. They had had some experience in propositions for the appointment of unpaid Commissioners; but none had ever been appointed, and that would probably be the result of the proposal in the present Bill. In calling upon Mr. Lloyd Wise to reply on the discussion, he expressed the thanks of the Society of Arts to that gentleman for the interest with which he had taken up the subject in his able paper.

Mr. Lloyd Wise, in reply, said:—Notwithstanding the exhaustive discussion we have had, I venture to hope you will allow me to trespass a little more on your valuable time, because, in view of what has fallen from various speakers, I desire, on some points, to supplement my paper. I think the following conclusions may fairly be drawn:—(1.) That the Attorney-General is sincerely desirous of establishing our Patent-law on a satisfactory basis. (2.) That it is not good policy to accept an indifferent measure in the eager desire to settle the question, and in the hope that those features wherein the Government Bill is superior to the existing law, will compensate, or more than compensate, for those in which it is inferior. (3.) That the Act of 1852 thoroughly administered would probably be, on the whole, more satisfactory than a law based on the Government Bill without amendment. (4.) That the Government Bill may be readily so amended and administered as to be far superior to the present law. (5.) That paid Commissioners should be substituted for unpaid Commissioners. (6.) That the proposed term of 24 years is not too long, especially in view of the fact that the average of the terms of prolongations granted by the Privy Council has been six years. (7.) That the powers the Government Bill, as it stands, would give to the Commissioners are too extensive, and the mode in which they are to be exercised is not sufficiently defined. (8.) That the present Government fees, and those proposed in the Government Bill, are much too high, and especially so in view of the fact that the Attorney-General himself assumes that, in the majority of cases, additional fees for amendment will have to be paid, since he says the cost of a patent will be usually £17 10s. (9.) That the deposit of models should not be required. (10.) That the publication of the full descriptions of inventions before the granting of patents would be unjust and impolitic. (11.) That great care should be exercised not to place undue power in the hands of Patent-office officials, and reports containing their opinions should not be published. (12.) That a patent should not be refused, in an unopposed case, on account of any supposed want of novelty or utility of the invention, but should be granted, at the applicant's risk, for what it is worth. (13.) That what is called racing for the seal should be stopped, and, in the absence of fraud, every patent should bear date as of the day on which the provisional protection was applied for. (14.) That the duration of a patent here should not be influenced by the circumstances of the invention having emanated from abroad, or having been patented in any foreign country or colony. (15.) That a patent should not be liable to revocation for non-working. (16.) That any enactment rendering compulsory the granting of licenses would have the effect of deterring manufacturers from first taking up and working the new inventions of

others, especially if they involved a large outlay of capital to test and to introduce, and would lead to much uncertainty about patent property, and to a considerable amount of litigation. (17.) That, so far as it goes, the clause in the Government Bill is satisfactory which provides that the validity of a patent granted here, in respect of an invention previously patented abroad, shall not be affected by the publication in the United Kingdom of the invention, through the circulation and re-publication here, within six months, of copies of any foreign or colonial grant in respect of the invention, or of any specification or other document officially connected with a foreign grant. (18.) That there should be thoroughly good indexes with clear illustrated abridgments arranged in classes, and always kept up to the latest possible date. (19.) That the registration of patent agents, and making them answerable for misconduct, would be a step in the right direction, it being clearly understood that every inventor should be free to take out a patent for himself without the intervention of an agent, just as every man is at liberty to be his own lawyer. I feel bound to state at the outset, that I think, with the Glasgow inventors, we had better have no legislation at all rather than have the Government Bill as it stands, and I say this because I feel that in accepting that measure we should be plunging into the dark. It is true that, in the main, a law based upon that Bill might be so carried out as to give very satisfactory results, but what the actual working of it would be is much too uncertain to justify its acceptance without explanation, especially when we are told, as we were by Mr. Coryton, that it would lead to abolition of patents. There are some gentlemen whose opinions are of the highest value, and among them I may name Mr. Hinde Palmer, Mr. E. A. Cowper, and Mr. Tweddell, who say "carry out the Patent-law Amendment Act of 1852 thoroughly. Appoint paid Commissioners, then we shall have a number of abuses and errors corrected, and afterwards we can make any improvements that appear needful." I gave evidence in this sense before the Select Committee of 1872, and I would rather see that course adopted than have the Attorney-General's Bill in its present shape. On the other hand, if we could see some of the objectionable features eliminated from that Bill, we undoubtedly should, as Mr. Trueman Wood has well said, get a much better law than that of 1852. It is, however, not desirable the Lord Chancellor and unpaid Commissioners should have the very extensive powers the Attorney-General's Bill would give them, because such powers might not always be exercised in a satisfactory way, although capable of being so exercised. Much has been said about the fees which should be charged on a patent, and, after the strong expressions of opinion we have heard in this direction, I may be permitted to say that I think the stamp duties proposed by Mr. Anderson in his Bill, viz., £10 for the first seven years, £25 for the second seven years, and £50 for the third period of seven years, would work out satisfactorily. Whether these stamp duties should be levied in the precise manner he has suggested may be matter for consideration. In some respects I am disposed to favour annual payments, as proposed by Mr. Olrick and Mr. Hunt. It has been said they would increase the risks of forfeiture, but my experience goes to show that there is less danger of this where the payment has to be made each year than is the case where several years elapse before payment becomes due. It is comparatively easy for a man to make an entry in his diary for a particular day in each year, but a matter to be attended to say seven years hence may be miscalculated, or the note of it may be overlooked or mislaid. We have heard much about the cheapness of patents in the United States, but this has been greatly exaggerated, inasmuch as in that country even modifications of the same machine frequently have to be made the subjects of separate patents, whereas, in the United Kingdom, it is, as Mr. Olrick has pointed out, by no means an unknown thing for one patent to be made to cover as much invention as twelve, or even more American patents. It must also be recollected, we have at present no model to provide and file, which in many cases is an important consideration. The model in a single case sometimes represents larger outlay than the Government fees on a dozen United States patents. I sent out one lately worth as much as it would cost to go to the United States, take out a patent, pay for it, and come back. To charge a high duty is to proceed on the assumption that the patentee gets an exclusive privilege in exchange for mere money, and that by the granting of a patent the public is a loser to the extent of the amount demanded from the patentee as consideration for the grant, whereas, in fact, the public is not the loser but a gainer—a gainer to an incalculable extent; and the patent or exclusive privilege is given not for or in consideration of the mere money payment exacted from the patentee, but in exchange, and by way of consideration for the benefit he confers by disclosing his invention to the public. This being so, it would seem not illogical to say that the full disclosure of a new and useful invention, with the manner of carrying it into practical effect, ought, in itself, to be deemed ample consideration. I do not go so far as to say this theory could, in practice, be successfully applied to its full extent, but I think the more closely we adhere to it the more we shall attain to a perfect Patent-law. It must be recollected that the privilege given by a patent applies only to the thing the patentee has disclosed, so that the privilege will be worthless if the invention or so-called invention be worthless, and the reward the patentee will get if the invention be really useful will only be proportionate to the actual value of the invention as proved in competition with other inventions in the open market. Some people seem to think that reduction of fees would mean the patenting of a larger number of frivolous inventions. This is entirely an erroneous supposition. As a matter of fact, the inventions now shut out are not shut out because they are frivolous, and, comparatively speaking, not worth the fees, but simply because the inventors cannot command the necessary funds. Inventions coming from practical men, such as workmen and others of limited means, are exactly those which the law should strive to secure for the benefit of the public, and, in this sense, reduction of fees would most unquestionably tend to the public benefit. The present high fees do not stand in the way of persons who can command funds patenting inventions of doubtful value. But a workman, after having secured his invention, would be compelled to show that it really possessed some practical value, otherwise he would fail to get it taken up, and, under the system of periodical payments, the patent would die out if the thing secured proved valueless. Either patents are advantageous to the community or they are not. If they were not advantageous, public feeling would not be slow to indicate that they should be done away with. In point of fact, however, public feeling is entirely in the other direction. The reason is that the public benefits by the industrial progress resulting from the inducement that Patent-law gives. Why, then, should this inducement be restricted to those who command money? Why should not an equal inducement be held out to those with brains and no money? We must all know that many valuable inventions are made by persons who cannot afford to patent them; and I am afraid I must say that as one result, it not unfrequently happens that a patent is taken out in the name of the party finding the money instead of the actual inventor, notwithstanding this involves a false declaration. Then, as regards the extension of the term, it seems to me that if the power of prolongation is to be taken away, the term of seventeen years, which has been proposed by some, would be utterly inadequate in those very cases where the additional term is most needed, and that no

logical objection has been shown to the proposed term of twenty-one years, which is the shortest that ought to be adopted, especially while other countries, including Belgium and Spain, give twenty years. I think the discussion which has taken place will satisfy the framers of the Bill that to make public a complete specification before the issue of a patent would give general dissatisfaction, besides giving the law officers more work than they could get through. Mr. Cowper has well indicated the unsatisfactory manner in which proceedings are conducted before the law officers, and I may state that this very day all my arrangements have been upset by having to attend to an opposition case at the Solicitor-General's room, at the House of Commons, at the late hour of 5.30 p.m. It needs experience to appreciate the trouble this sort of thing involves. In this case it was desirable to show large heavy models of machinery to the law officer, and these had to be sent on to the House of Commons before two o'clock, so as not to be in the way of members assembling; men had to be kept in attendance for hours to watch these models, and to bring them away after the hearing; the Solicitor-General had to go out of his own room to inspect the models; to say nothing of the inconvenience caused to counsel and others by having to commence arguing a case at so late an hour. I often feel amazed when I think of the Attorney-General's proposal to alter the law, so that it should lead to a greater number of these most unsatisfactory hearings before law officers. The costs to inventors are very heavy, almost as heavy as those of a law suit, because counsel are employed and scientific evidence and models are put in; and considering the hurried manner in which the proceedings are gone through, it cannot be said the result is usually satisfactory. Mr. Trueman Wood doubts whether the Bill means opposition on open documents. I admit the Bill itself leaves this open to doubt, but the general opinion of experienced practitioners, in view of the order in which the several provisions appear, is that publication of the complete specification is intended to take place before the time for opposition. Where the law officer has to decide in a case of opposition, if he is to be the judge, it is reasonable he should have before him the complete specification; and, practically speaking, the draft of that document does go before the law officer or the Lord Chancellor, where there is opposition under the present law, unless the applicant has himself elected to file a full specification in the first instance; but the full description is not made public until the case is decided, therefore, if the patent be refused, the applicant is still able to secretly use any novel feature he may have intended to describe in his complete specification. It is an objection to the present practice that all opposition has to be conducted in the dark, which often results in more or less hardship. A person having an interest, and failing to oppose, may be told that he had his opportunity and failed to avail himself of it, although, as a matter of fact, he may have known nothing more than that the applicant he should have opposed was applying for a patent for improvements in steam-engines. On the other hand, had he opposed in ignorance of the contents of the provisional specification, and simply on the ground that he knew the applicant was seeking to patent some improvements in steam-engines which possibly might affect him, the opponent, he might be mulcted in the cost, and told he should not have wasted the law officer's time by opposing without any reasonable grounds. Undoubtedly, the first thing to do to correct such evils is to insure that all patents shall be sealed as of the date of the original application. In other words, to stop all possibility of racing for the great seal. The next thing is to provide that a patent obtained in the name of the true inventor shall not be fatal to a patent afterwards obtained by the true inventor. It seems to me that with these provisions, and such ready means as the Attorney-General's Bill provides for getting rid of a bad patent, by petition to the Lord Chancellor, publication of the specification before granting a patent would become needless. If, however, there should be a majority of the contrary opinion, I would suggest the consideration of a medium course, such as permitting the provisional specification (not the complete specification) to be inspected by any person who, in a statement to be verified by affidavit, should show that he had reasonable ground for suspecting that, for reasons set forth in his statement, the patent sought for ought not to be granted. At the present time, if by accident or inadvertence an applicant for a patent fails to take a particular step within the prescribed time, as, for instance, if he fails to file a specification within six calendar months, he petitions the Lord Chancellor, setting forth the circumstances in his petition, to the accuracy of which he swears before a Commissioner. Where he does the work himself the only outlay is 1s. 6d. for the Commissioner's fee. The Lord Chancellor, on such a petition, if the application be at all reasonable, usually grants leave to take the step, notwithstanding that the prescribed time has elapsed. Now, it seems to me that an analogous mode of petitioning might be adopted for seeking leave to inspect provisional specifications before entering an opposition, that is to say, if we are to have an inspection at all, I would do it in this restricted way, and certainly not by publication of the complete specification. I would also suggest it should be distinctly provided that no such special opening to inspection or publication resulting therefrom should be regarded as in a legal sense publication. Of course the applicant for a patent should not be required to describe in his provisional specification the manner of performing his invention. While I quite approve of laying before the law officer or the Lord Chancellor, as the case may be, a full description in a case of opposition, I totally dissent from the proposition that equally full particulars should be placed in the hands of an opponent. The most he should know is that there is a reasonable probability that his interests will be affected by the granting of the proposed patent, and that there is reasonable ground for supposing it ought not to be granted, or if granted, ought to be subject to restrictions. If he is satisfied of that much, it is clearly for him to make out his case, and not for the law to require the applicant to furnish the opponent with particulars which will enable him to make up or strengthen his case, perhaps in a dishonourable way. I think it has been clearly shown that any attempt to introduce a system of preliminary examination under which patents should be refused, on the ground even of want of novelty, would be unsatisfactory in the extreme. It is true there is a sort of preliminary examination at present. All applications for patents are numbered consecutively, commencing anew each year. Those bearing odd numbers go to the Attorney-General; those bearing even numbers to the Solicitor-General. Each law officer has a patent clerk, who makes the examination. In practice, one law officer's clerk will sometimes pass a provisional specification such as another law officer's clerk would have objected to. Moreover, one law officer, through pressure of business, may keep an application a month and then raise an objection, while the other law officer may allow a conflicting application within a week. Consequently, through no fault of his own, an applicant for a patent may, notwithstanding that he has used all possible diligence, find he has been beaten in the race. Hence, the present system is not altogether satisfactory, especially since a second applicant, by getting his patent sealed first, may stop an earlier application. As Mr. Hinde Palmer interprets the Government Bill, there is to be no such examination as was provided for in former Bills. I confess to a feeling of doubt on this point; but it is to be hoped the real meaning of the Attorney-General's Bill will be arrived at before it becomes law, and that he may, at

any rate, be induced to abandon any intention he may have of introducing here systems resembling in any way those which obtain in the United States and Germany, which result in frequent injustice to applicants whose patents are refused, and in misleading not only those whose patents are granted, but also the public. In Germany the description is made public before the grant of the patent, and this course, besides being objectionable on other grounds already alluded to, is attended with the additional evil that, where rival inventors are in the field, and the Patent-office officials make the earlier inventor's patent a ground of objection to the later applicant's request for a patent, even as the result of error in judgment, the earlier patentee may often be iuduced to suppose he has good ground for commencing proceedings for infringement of patent. At any rate, I know this to be the view taken in some cases, and I think the inference is not unnatural. As to the notion that after an application for a patent has undergone the ordeal of an official examination, accompanied by publication, the patent becomes a more valuable property, I cannot too strongly urge, as the result of considerable experience, that, in practice, those who may invest their capital on any such assumption will be running very serious risk of losing it. I say that in Germany, and also in the United States, notwithstanding all their examination, many utterly worthless patents are granted, and many applications are unjustly rejected without any good reason whatever, to the serious injury of the applicants and ultimate disadvautage of the country. Mr. Hinde Palmer expresses an opinion in which I cannot concur, that so experienced an authority, as a law officer might safely be left to decide whether a patent should be granted or not. That our law officers, besides being gentlemen of the highest legal attainments, are also clear-sighted, painstaking, and anxious to do full justice to each matter brought before them, I would be the last to deny. But it is clearly erroneous to suppose these qualifications are, or can be expected to be, such as to make them the right men for deciding such technical questions as disputed patent cases involve, and in practice I have found that a law officer has sometimes, from want of technical knowledge, decided against an applicant having a really good invention, and who has had no appeal; and I have also found that where the law officer could not make up his mind, he has given the applicant the benefit of the doubt. Then the opponent has lodged a *caveat*, and that has had the effect of stopping the applicant, because it has meant costly proceedings before the Lord Chancellor, which the applicant could not afford. The clauses as to compulsory working and compulsory licences are also clearly disapproved of. If we are to have either of these clauses, I would prefer compulsory licences, because I know, from practical experience, that compulsory working clauses lead to endless trouble and uncertainty without affecting the real object at which they aim. And if we are to have compulsory licences, perhaps the compromise proposed, I believe, by Dr. Siemens, might, with advantage, be adopted, that licences should only be compulsory where the patent relates to improvements in existing mauufacturing processes. I am not, however, at all sure this would work entirely well, and, it seems to me, periodical payments answer all purposes. The objections to the proposed clauses respecting imported inventions have been so thoroughly ventilated, that I need say no more about them, as I feel sure the Attorney-General will see the advisability of making material alterations in them. Mr. Sedgwick Woolley has well pointed out that we want better indexes, and generally greater facilities for the making of searches by inventors themselves at their own homes. I would add that the *Commissioners of Patents' Journal* should contain reports of Patent-law cases. As regards the provisions in the Bill for referring cases to Judges of the High Court, I confess I am not so sanguine as my friend, Mr. Alexander, who positively frightened me by naming that eminently scientific but strongly anti-patent Judge, Mr. Justice Grove. As regards the proposal, that patent-agents should be registered, which so many persons regard with favour, I may say I am informed that the late Mr. Bennet Woodcroft, F.R.S., who was practically at the head of our Patent-office, was strongly of opinion that something of the sort should be done.

A vote of thanks to Mr. Lloyd Wise for the paper was carried unanimously.

The **Secretary** read the following letters:—

Mr Ralph Tweddell writes:—

"I much regret that I cannot attend the adjourned meeting for the discussion on Mr. Wise's valuable paper. After a careful perusal of it, I can only conclude that, in common with many others, he does not see any very urgent necessity for further legislation, but is of opinion that, if the Act of 1852 were carried out in its integrity, there would not be much ground for complaint. I took considerable interest in opposing the Bill of 1875, and I then expressed an opinion that the agitators, who were so busy, had better take care, lest they 'jumped out of the frying-pan into the fire.' It should not be forgotten that there is much to be said against granting patents at all, and, putting aside one or two men with extreme views, that some of our clearest-headed public men are not with us; let us take care that we do not put them actively against us. Practically, some such incentive as is given by a Patent-law is, I believe, absolutely necessary, in order that sufficient inducement may be given to an inventor to work out his invention, so as to be useful to the public as well as to himself. I think that the interests of practical patentees are just now very apt to be injured by the too enthusiastic advocacy of some and asking too much by others. After all, a new Patent-law is not everything, although a very important matter, and when one reads such remarks in a previous discussion on the paper, as the following—'If we desire to restore this country to its former proud position amongst the nations of the globe, we must improve the Patent-law, since without that it would be vain to rely on free trade or anything else.' One cannot but fear their result on less enthusiastic, but more legal minds, putting aside the allusion to 'free trade,' or anything else—when it is 'protection' we are clamouring for. I utterly demur to the assumption that this country has yet lost her position, and in support of my view of the case I would refer any one to the Paris Exhibition, and to the testimony given both in official and private reports thereon. I do not deny that other nations are running us closer, but I suppose Oxford would sooner be a 'tie' with Cambridge than a hundred lengths ahead of a Thames punt. So much for the applied sciences, and as to technical education, I thiuk the recent discoveries of Thomas Gilchrist and Snelus go far to prove that a 'School of Mines' is as good as any 'Ecole Polytechnique;' this is rather a digression, but it goes to prove that even under the Act of 1852, utterly unworked as it has been, this country has not only held its own, but acted as an incentive to further progress and educated other nations also. As to the cost of obtaining a patent, I think a great deal too much is made of the great number of patents hatched in America owing to the small fees. The quality of many patents taken out here is not good, but it would be very much worse were the total tariff to lowered. I believe that the same beneficial effects, as to the quality of patents, would follow in America were the fees higher, as occurred in this country when dog licenses were raised from 5s. to 7s. 6d.; there are fewer dogs about, and they are of better quality. Hydrophobia became much more rare

also, and judging from many of the ideas patented, we can, I think, safely predict a satisfactory decrease in that form of insanity. I believe, however, in reducing the preliminary fees, but only by spreading the payments over a longer period, and if a patent after seven years can't afford the £100 stamp, it cannot possess much value, either to its owner or the public. Numerous as the inventions in America are, I should prefer one invention by a Siemens or a Bessemer to 10,000 apple parers, or similar dodges; and where are the great inventions of America? Furthermore, I have not experienced in practice that patents in the States can be got so cheap. You get a very good patent in America by paying a good sum for it, and, on the other hand, a poor one by paying the mere fees only. I am not at all sure, taking into account the number of claims you can embrace in an English patent, that you cannot get one here as cheap if you wish. I think all questions of preliminary examination and reports most dangerous, and I think the French plan the best which, I believe, gives no guarantee at all on the part of Government. I think that the Government should provide a sufficient staff to enable inventors, who are either too poor or unwilling to employ skilled patent agents, to comply with the legal forms, and to advise them, generally, as to what they can legally protect. This brings me to a portion of the paper, which I think deserves more attention than has yet been given to it, and it is the suggestion made by the late Mr. Hindmarsh, that the names of the existing patent agents should be registered, and that no person be permitted to practice without examination, &c. I am quite sure this would gratify the leading members of a most difficult and arduous profession, and it would save not only the poor inventors, but all patentees much loss and trouble. I do not think there is anything on earth I would hesitate more to undertake than the drawing up of a patent specification, and yet it is done daily by many who are not patent agents at all, who, in other words, have neither the legal nor the technical education. I think a patent agent should be a combination of both. Some of the best patents are lost, not because of any want of utility or novelty, but because they are badly drawn up. I would make it compulsory for every patent specification to bear the name of the patent agent who drew it up. I think Government might interfere here. They do not permit anyone to register the birth, or for that matter, the death of our offspring, why should they pay less attention to the offspring of what we are pleased to term our brains? I have already written too long a letter, but I cannot close without endorsing Dr. Siemens' remarks, as to assigning a patent, even if not of his own invention, to some one to work it out. In practice, any act to be workable must consist of compromises, and after all, we only want the Act of 1852 worked in a liberal spirit, and I think, that both in granting and upholding patents, the Crown should be guided more by their utility and practical application than by mere questions of priority and imagination. Any one can invent, if he has an imaginative mind, but this hould not, as it now too often does, shut out the man who has both this gift, and also that of applying it for the good of his fellows and of himself. In conclusion, I observe that a museum is contemplated. From previous experiences of Government museums, I should object to Government having anything to do with it. But I think a museum in connection with the Hall of Science, towards the promotion of which one of our most eminent patentees, Dr. Siemens, has so generously contributed, would be the most beneficial to the general public. A certain portion of patent fees, aided by Government, should be set aside towards the expenses, and committees of the various scientific bodies using the Hall should manage it. Applied sciences would then, indeed, be suitably housed, and combine under one roof past and present inventions and lessons for future guidance."

Mr. Bristow Hunt writes:—

"On the kind invitation of the Council, I attended when Mr. Lloyd Wise read his very able paper on the 'Government Patent Bill,' and also when the adjourned discussion took place.

"As, no doubt, when the further discussion is held, there will be many gentlemen desirous of speaking on the subject, who will be better able to do so than I am, I have thought that, instead of taking up the time of the meeting, it would be better to put into writing my suggestions for amending the Patent-law, in the hope that they may be found worthy of consideration.

"With regard to the cost of patents, I would propose that the total stamp duty, or Government fee cost of a patent, completed and sealed, and the final specification filed, should not be more than £25 (as now), but instead of that sum having to be paid (as now) within six months, its payment should be spread over the first five years of the term of the patent; that is, £5 of it should be paid each year.

"After that, I think it would be a very equitable plan, both for the Government and the patentee, if, in lieu of any further fixed stamp duties, the patentee or assignee should pay annually to Government a certain moderate per-centage on the profits made under the patent, something in the way that income-tax is paid. Thus, the more valuable and profitable the patented invention, the better it would be for our country's revenue.

"I quite agree that a patent should be granted for 21 years, and no prolongation thereafter.

"I would also suggest that on the patentee or assignee failing to pay the annual per-centage on the profits, the patent should then expire.

"According to my experience of the working of the 1852 law (and I have practised as a solicitor and patent agent, conjointly, for 23 years), it has been the paying in one lump sum of the large stamp duty of £50, at the end of the third year, and the much larger, and, in many instances very difficult to provide, seventh year's stamp duty of £100, that patentees (I may say of all classes) and assignees have so very often and so strongly objected to.

"If we compare the numbers of British patents applied for in 1877 (namely 4,949) with those applied for in France in the same year, which were 7,101 (including certificates of addition), where the Government cost of a patent is only £4 per annum, I think it would be found that were we to have a somewhat similar annual system of payments, our revenue would benefit very largely therefrom, and the reduction in cost would stimulate the British inventor to increased progress in invention.

"In the United States in the same year (1877) 20,308 patents were applied for, out of which no less than 13,619 were granted (after the official examination there required), and as a patent for the United States granted for 17 years only costs some £25, including an ordinary specification with drawings and a model, I think this proves conclusively that if British patents were made less costly, both inventors and the revenue would greatly benefit thereby.

"In conclusion, I would observe that the recommendation in Mr. Wise's paper, that patent agents should be under some official control or be duly qualified, on examination as to competency, to practise as such (as solicitors are), cannot be to strongly urged, for it is well known that there are many self-constituted patent agents who are not competent to practise as professional patent agents.

"A barrister told me the other day that it was a point the Law Institution could and ought to raise, whether

a so-called and self-constituted patent agent, not being a solicitor, can legally charge and recover his charges for drawing or preparing such an essentially legal a document as the specification in pursuance of Letters Patents is or ought to be? Certainly they cannot legally prepare assignments of or licenses under patents, or any agreements relating thereto."

Mr. John Murray writes:—

"I have taken a deep interest in the subject of the Patent-laws; and I have, therefore, read with much care and attention the paper on the 'Government Patent Bill,' which Mr. Lloyd Wise placed before the Society of Arts, on the 7th inst. Agreeing with Mr. Wise, as I do, on all the material points which he advocates, I was much struck with his reference to the great advantage which would result to the working of the Patent-laws, from the embodiment and registration of patent agents, as a class.

"I think that while such a measure would be gratefully accepted by the existing patent agents as a body, it would not only tend to ensure their efficiency, but would operate as a check to the admission of incompetent, and otherwise objectionable persons upon the register in future.

"I trust that the reference to this important point may receive attention from the promoters of the Bill."

CORRESPONDENCE.

NATIONAL WATER SUPPLY.

On page 619 of your last issue, I find the following remarks by Mr. Baldwin Latham: "With regard to water from the red sandstone, he understood that the Corporation of Liverpool had abandoned the deep well for procuring additional water supply, because the deep boring, carried to a depth of 1,300 feet, was shown to yield no more water than the shallow borings, and they declined to go to any further expense."

It is from remarks like these, conveyed to gentlemen of Mr. Latham's position, and made public by them to all who feel a deep interest in what concerns the obtaining of a pure and wholesome water for domestic use, that I complain.

What I have quoted does not contain one word of truth, and no one employed at the works visited by Mr. Latham was his informant; yet, that such a statement has been made, on which full reliance has been placed, there can be no doubt. The question is, by whom? I have written to Mr. Latham, but his reply will not reach me in time for your next publication; therefore I beg of you to insert this in the *Journal* of the 13th inst. I am sure Mr. Latham would make the same request if he knew how grossly he has been imposed upon.

W. Bennett,
Member of the Liverpool Water Committee.

Heysham-tower, Lancaster, June 11, 1879.

Errata.—P. 579, middle of second column, add + OH_2 to the equation; p. 581, middle of first column, read $SO_4 H_2$ for $2SO_4 H_2$, and SO_2 for $2SO_2$; also, in equation eleven lines lower down, read SO_2 for $2SO_2$; p. 600, second column, read 95,000 tons for 950,000 tons.

NOTICES.

SANITARY CONFERENCE.

The Pamphlet containing a full report of the papers and proceedings of the late Conference on National Water Supply, Disposal of Sewage, and Health, will be published shortly, price 2s. 6d.

Applications for copies of the Report should be addressed to the Secretary.

MEETINGS FOR THE ENSUING WEEK.

Mon., June 16th...**SOCIETY OF ARTS,** John-street, Adelphi, W.C., 4 p.m. Special General Meeting, to consider alterations of Bye-Laws.
Victoria Institute (at the House of the Society of Arts), 8 p.m. Annual Meeting. Address by Dr. C. B. Radcliffe.
Royal United Service Institution, Whitehall-yard, 8½ p.m.
Asiatic, 22, Albemarle-street, W., 3 p.m.

Tues., June 17th...Statistical, Somerset-house-terrace, Strand, W.C., 7¾ p.m. Dr. Guy, "Tabular Analysis;" and, time permitting, extracts from a paper by Dr. Cornish on "The Influence of Famine on Growth of Population."
Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. J Gwyn Jeffreys, "The Mollusca procured during the *Lightning* and *Porcupine* Expeditions, 1868-70." Part II. 2 Mr Edward R. Alston, "The *Acanthomys leucopus* of Gray." 3. Dr J. Murie, "The Manatee."

Wed., June 18th...Meteorological, 25, Great George-street, S.W., 7 p m. 1. Mr. Robert H. Scott, "Report on the International Meteorological Congress held at Rome, April, 1879." 2. Mr. William Marriott, "Thermometer Exposure—Wall *versus* Stevenson's Screens." 3. Mr. Charles Meldrum, "The Hurricane at Mauritius on March 20th-21st, 1879." 4. Mr. William Ellis, "A Remarkable Disturbance of Barometric Pressure observed at the Royal Observatory, Greenwich, on May 18th, 1878." 5. Mr. Charles N. Pearson, "Meteorology of Mozufferpore, Tirhoot, 1878."
Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Mr W. Money "Discovery of Roman Remains at Hampstead Norris" 2 Mr. G. G Adams, "Coronation Medals of George II., by German Artists" 3. Mr. W. de Grey Birch, "Inscribed Stone in Ely Cathedral."

Thurs., June 19th...Royal, Burlington-house, W., 8½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
Linnean, Burlington-house, W., 8 p.m. 1. Mr. F. M. Bailey, "Carpesium as Indigenous to Australia." 2. Messrs. J. G. Baker and S. Le Marchant Moore, "Flora of Northern China." 3. Prof. G. Busk, "New Polyzoa." 4. Rev. J. M'Crombie, "Australian Lichens, of R. Brown's Herbarium."
Chemical, Burlington-house, W., 8 p.m. 1. Dr. Stenhouse and Mr. Groves, "Gardenine." 2. Drs. Armstrong and Tilden, "The Action of Sulphuric Acid on the Hydrocarbons of the Formula $C_{10} H_{16}$." 3. Dr. Armstrong, "Researches on the Terpenes, Camphor, and Allied Compounds." (Parts I. and II.) 4. Mr. H. T. Brown, "Contributions to the History of Starch and its Transformations." 5. Dr. Carnelly and Mr. W. C. Williams, "The Boiling Points of Certain Metals and Metallic Salts." 6. Mr. R. Warington, "The Determination of Nitric Acid by Means of Indigo." 7. Dr. Gladstone and Mr. Tribe, "Dry Copper-zinc Couples and Analogous Agents." 8. Mr. R. Schunck, "Notes on the Purple of the Ancients."
Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. The Third Conversazione.
Numismatic, 4, St. Martin's-place, W.C., 7 p.m.
Philosophical Club, Willis's-rooms, St. James's, S.W., 6½ p.m.
Institution of Mechanical Engineers, 25, Great George-street, S.W., 7 p.m. 1. Mr. David Greig, "The Strength of Steel and Iron Boilers." 2. M. Anatole Mallet, "The Compounding of Locomotive Engines." 3. Mr. J. H. Greathead, "Injector Hydrants." 4. The Hon. R. C. Parsons, "The Loss of Power in the Screw Propeller, and the Means of Improving its Efficiency."

Fri., June 20th...Royal United Service Institution, Whitehall-yard, 3 p.m. Colonel Nugent, "The Defence of Capitals."
Philological, University College, W.C., 8 p.m. Mr. R. N. Cust, "The Languages of Africa."
Institution of Mechanical Engineers, 25, Great George-street, S.W., 7 p.m. Papers and discussion continued.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,387. Vol. XXVII.

FRIDAY, JUNE 20, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

FINANCIAL STATEMENT.

The following statement is published in this week's *Journal*, in accordance with sec. 40 of the Society's Bye-laws:—

TREASURERS' STATEMENT OF RECEIPTS, PAYMENTS, AND EXPENDITURE, FOR THE YEAR ENDING MAY 31st, 1879.

Dr.

	£ s. d.	£ s. d.
To Cash in hands of Messrs. Coutts and Co., 31st May, 1878	785 6 1	
Do. do. ... Secretary ...	16 15 10	
		802 1 11
,, Subscriptions received during the year from Members and Institutions in Union	6,126 11 6	
,, Life Contributions	346 10 0	
		6,473 1 6
,, Dividends and Interest...		616 19 1
,, Sale of Stock to meet Cost of Repairs to Premises		318 6 6
,, Examinations (Commercial, &c.):—		
Prince Consort's Prize (H.M. the Queen)	26 5 0	
Fees, &c....	43 14 6	
Ditto (Technological):—		
Donation by Clothworkers' Company for payments to teachers	141 0 0	
,, (G. N. Hooper, Esq.) ...	10 10 0	
		221 9 6
,, House and Office (receipts for gas) ...		25 1 0
,, Advertisements		1,594 3 4
,, Sales:—		
Journal	120 8 9	
Cantor Lectures	7 3 5	
Sanitary Conference Reports ...	19 16 2	
Domestic Economy ,, ...	2 0 8	
Spoiled Post-cards	1 12 4	
Transactions	1 14 6	
		152 15 10
,, National Training School for Music (Exam. Fees)		3 0 0
,, National School of Art Wood-carving:—		
Donation by Drapers' Company...		155 0 0
,, Memorial Tablets:—		
Donation per H. D. Pochin, Esq. ...		25 0 0
,, Domestic Economy Congress:—		
Payment from Manchester Committee towards expenses		67 0 0
,, Donations to Artisans' Reports Fund (Paris Exhibition, 1878)		514 0 0
		£10,967 18 8

Cr.

	£ s. d.	£ s. d.
By House and Premises:—		
Rent, Rates, and Taxes	334 16 8	
Insurance, Gas, Coal, and House Charges...	231 2 2	
Repairs and Alterations	474 18 0	
		1,040 16 10
,, Office:—		
Salaries, Wages, and Commissions ...	1,689 16 2	
Stationery and Printing	290 4 7	
Advertising	45 1 8	
Postage Stamps and Parcels	189 11 7	
		2,214 14 0
,, Library, Bookbinding, &c.		68 7 0
,, Conversazione		256 7 6
,, *Journal*, including Printing, Stamps, and distribution		2,704 13 11
,, Advertisements (Agents and Printing)		834 15 1
,, Union of Institutions, including Commercial Examinations, Prizes, Fees,		
Postage, Printing, &c.	562 1 2	
Prince Consort's Prize	26 5 0	
Technological Examinations, including Prizes, Fees, Printing, and payment to Teachers... ...	305 11 6	
		893 17 8
,, Balance of Clothworkers' Company's Scholarship to J. Heywood ...		26 5 0
,, Conferences on Health, &c., and on Water Supply (including the publication of "Notes on Previous Inquiries")		482 0 4
,, Domestic Economy Congress		150 4 5
,, Medals:—		
Albert	24 0 6	
Society's	35 13 0	
		59 13 6
,, Prizes—		
Swiney	100 0 0	
Owen Jones	33 0 0	
Blowpipe	10 10 0	
		143 10 0
,, Cantor Lectures		176 8 0
,, Juvenile Lectures		21 9 0
,, Sections—		
African	61 18 6	
Chemical...	61 14 0	
Indian	66 4 0	
		189 16 6
,, National Training School for Music, including Society's Scholarships (£160)		169 4 9
,, National School of Art Wood-carving (scholarships, etc.)		155 0 0
,, Committees:—		
General	12 14 0	
Saving Life at Sea	11 12 3	
Universal Catalogue of Books ...	7 7 0	
Musical Education	5 11 0	
		37 4 3
,, Donation to African Exploration Fund		10 0 0
,, Annuity to Mrs. Cantor		25 0 0
,, Artisan Reporters' visits to Paris Exhibition, 1878		498 8 10
,, Investment of Life Donations in Purchase of £356 6s. 0d. Reduced 3 per Cents		346 10 0
		10,504 6 7
,, Cash in hands of Messrs. Coutts and Co., 31st May, 1879	455 8 3	
,, Ditto in the Secretary's hands ...	8 3 10	
		463 12 1
		£10,967 18 8

Liabilities.	£ s. d.	£ s. d.
To Tradesmen's Bills	1,019 10 2	
,, Rates	41 13 4	
,, Prince Consort's Prize	26 5 0	
,, Examiners' Fees (Commercial, &c.) ...	178 10 0	
,, Examination Prizes (Commercial, &c.)	140 10 0	
,, Sir Walter Trevelyan's Prize	100 0 0	
,, Sections:—African, Chemical, and Indian	180 0 0	
,, Saving Life at Sea, Prize Medal ...	20 0 0	
,, Swiney Prize Cup	100 0 0	
,, Artisans' Paris Reports Fund:— Balance of Donations ... 111 7 7; Council Vote 105 0 0	216 7 7	
		2,022 16 1
By Balance of Assets over Liabilities ...		6,470 1 3
		£8,492 17 4

Assets.	£ s. d.	£ s. d.
By Society's Funds invested in— Reduced 3 per Cent. Stock £3,463 4s. 0d., worth on 31st May, £3,359 5s. 0d., less £571 12s. 6d. reserved to meet Trusts stated below	2,787 12 6	
Great Indian Peninsula Railway 4 per Cent. Debenture Stock	200 0 0	
		2,987 12 6
,, Subscriptions of the year uncollected .	863 2 0	
Arrears, estimated as recoverable ...	400 0 0	
		1,263 2 0
,, Barry's Pictures and other property...		2,000 0 0
,, Prince Consort's Prize		26 5 0
,, Advertisements on the Books* ...		1,622 5 9
,, Donations to Artisans' Reports Fund still due		30 0 0
,, Cash in hands of Messrs. Coutts and Co., 31st May	455 8 3	
Ditto on Deposit	100 0 0	
Ditto in hands of Secretary (Petty Cash)	8 3 10	
		563 12 1
		£8,492 17 4

* A portion of this sum is still subject to charges for printing.

Stocks and Cash Statement Standing in the Name of the Society.

Consols ...	£4,891 6 4
New 3 per Cents. ...	388 1 4
Reduced 3 per Cents. ...	3,463 4 0
United States 5 per Cent. Funded Bonds, 1871 (2,500 dollars) ...	509 1 3
Oude and Rohilcund Railway 5 per Cent. Guaranteed Stock...	2,150 0 0
Bombay and Baroda ,, ,, ,, ,, ...	2,450 0 0
Canada 4 per Cents. ...	423 0 0
India 4 per Cents. ...	105 18 7
Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock ...	2,170 0 0
Metropolitan 3½ per Cent. Stock ...	343 14 3
Cash in hands of Messrs. Coutts and Co., on deposit ...	100 0 0

Trust Funds Included in the above.

1.	Dr. Swiney's Bequest ...	£4,500 0 0	Consols, chargeable with a sum of £200 once in five years.
2.	John Stock's Trust ...	100 0 0	,, ,, the Award of a Medal.
3.	Benjamin Shaw's Trust for Industrial Hygiène Prize ...	133 6 8	,, ,, ,, Interest as a Money Prize.
4.	North London Exhibition Trust ...	157 19 8	,, ,, ,, ,, ,, ,,
5.	Fothergill's Trust ...	388 1 4	New 3 per Cents., chargeable with the Award of a Medal.
6.	J. Murray, Esq., in aid of a Building Fund ...	50 0 0	Invested in Reduced 3 per Cent. Stock.
7.	Subscriptions to an Endowment Fund ...	431 12 6	Invested in Reduced 3 per Cent. Stock.
8.	Dr. Aldred's Bequest ...	90 0 0	Invested in Reduced 3 per Cent. Stock.
9.	Thomas Howard's Bequest ...	500 0 0	,, ,, United States 5 per Cent. Funded Bonds, 1871.
10.	Dr. Cantor's Bequest ...	5,052 19 8	,, ,, Bombay and Baroda and Oude and Rohilcund Guaranteed Railway Stock.
11.	Owen Jones Memorial Trust ...	400 0 0	,, ,, Canada 4 per Cent. Stock.
12.	Mulready Trust ...	109 12 9	,, ,, India 4 per Cent. Stock.
13.	Alfred Davis's Bequest ...	1,800 0 0	,, ,, Great Indian Peninsula Guaranteed Railway Debenture Stock.
14.	Memorial Window Fund ...	345 0 0	,, ,, Metropolitan 3½ per Cent. Stock.
15.	Sir Walter Trevelyan's Prize ...	100 0 0	On Deposit with Messrs. Coutts and Co.

The Receipts of the Society set forth above have been credited by Messrs. Coutts and Co.
The Payments set forth above have been made by authority of the Council.
The Assets, represented by Stock at the Bank of England, and securities, cash on deposit, and cash balance at Messrs. Coutts, as above set forth, have been duly verified.

H. Reader Lack, B. Francis Cobb, } *Treasurers.*
J. Oldfield Chadwick, *Auditor.*
H. Trueman Wood, *Secretary.*

Society's House, Adelphi, 18th June, 1879.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Twenty-fifth Annual General Meeting, for the purpose of receiving the Council's report and the Treasurers' statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held, in accordance with the Bye-laws, on Wednesday, the 25th of June, at 4 o'clock p.m.

The Council think it well to call the special attention of Members to the above notice, and to express their hope that Members may find it convenient to attend, and receive the report of the Council on the work of the Session.

(By Order of the Council)
H. Trueman Wood,
Secretary.

The Chairman of Council will propose, pursuant to a resolution of the Council (May 12th, 1879),

"That a Grant of £100 per annum be made to Mrs. Foster for her lifetime, subject to revocation at any future Annual General Meeting, upon notice being given to the Secretary at least one month previous to such Annual General Meeting."

ALTERATION OF BYE-LAWS.

A general meeting of the members for the purpose of making certain alterations in the Bye-laws of the Society was held on Monday, the 16th June, at 4 p.m., Lord ALFRED S. CHURCHILL, Chairman of the Council, in the chair.

The various modifications in the Bye-laws, proposed by the Council, were carried, and the new edition of the Bye-laws, as altered, has been circulated among the members.

CONVERSAZIONE.

The Society's *Conversazione* is fixed to take place at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education) on Wednesday, the 25th of June. Cards have been issued to the Members.

SANITARY SECTION.

The following correspondence between the Right Hon. James Stansfeld, M.P., and Mr. C. N. Cresswell, Barrister-at-Law, has been laid before the Committee of the Sanitary Section of the Council, and is published by their direction:—

1, Hare-court, Temple, May 21st, 1879.

DEAR MR. STANSFELD,—In pursuance of our conversation at the close of the National Health and Sewage Conference, I take the liberty of communicating to you in further detail the nature and objects of the proposed organisation.

The Sanitary Section of the Council of the Society of Arts is at present occupied with the investigation of facts, and the collation of statistics bearing upon the sanitary condition of houses in the metropolis and suburbs; and, with the object of utilising the array of scientific data presented to them, I propose to organise, with the sanction of the Council, a new department, which, for lack of a better title, I will call the "Sanitary Inspection and Classification Department."

The public have sufficient confidence in the Society, to give ear to any practical suggestions emanating from its Council; but, whatever may be the intrinsic merits of my idea, I am well aware that it cannot be reduced to practice without the co-operation of architects, building-owners, contractors, surveyors, and sanitary engineers; and it will be indispensable to enlist their interest, moral and material, in the cause.

The *modus operandi* proposed is analogous to that pursued by the classification department of "Lloyds," viz., by granting certificates in different categories, as 100 A 1, 50 A 1, A 1 in red, B, and so forth, according to the mode of construction and seaworthiness of the vessel, as certified by surveyors, whilst upon the stocks, or undergoing repair.

In like manner, surveyors would be appointed in the metropolis and provinces for the purpose of inspecting and supervising the sanitary condition of houses, both during construction and repair, and certificates would be granted according to the degree of sanitary completeness attained.

The conditions and degree of classification would be determined by a code of sanitary regulations, to be framed by our Committee, and formally sanctioned by a Conference of architects, sanitary engineers, and contractors, to be convened by the Society for that special purpose.

By this means we should conciliate the objections of householders, and command the acquiescence of speculative builders.

Just as a ship is reputed, upon the certificate of "Lloyd's," to be seaworthy for a term of years, so would the houses of rich and poor be certified as healthworthy and fit for habitation, and this at a relatively small expense, which the increased repute of the houses certified, and the good sense of the public in selecting the good from the bad, would speedily recoup.

It is, of course, intended that the institution should be self-supporting by means of fees to be paid both for inspection during construction or repair, and upon delivery of the certificates of classification, which certificates would be title-deeds, to be preserved with other muniments, and an assurance to the purchaser or lessee of the sanitary fitness of the premises for habitation.

There are at present but few mansions in the metropolis whose sanitary condition will entitle them to an A 1 certificate. Thousands of them are defective in respect of drainage, ventilation, water storage, and other sanitary appliances, and in many conspicuous instances a large expenditure has been necessitated in order to render them habitable, a state of things which the organisation here foreshadowed would in process of time effectually remedy. After the first outlay for efficient sanitary equipment, the fees payable on registration and the cost of subsequent supervision will be inconsiderable.

To elaborate details and organise the department will require time, skill, and labour; moreover, there will be need of tact and patience, in order to overcome the repugnance of some and the *inertia* of others. I am, however, not dismayed by the prospect of obstacles to be overcome, if I may rely upon the support of a few earnest men, having weight and authority in the kingdom, in whose ranks I venture to include your name, as the President of our annual Conferences, and the tried friend of sanitary progress.

In conclusion, I would observe that the proposed supervision of the Society will be confined to sanitary equipment and appliances only, the method and details of construction in other respects being regulated by the provisions of the several Metropolitan Building Acts.

Yours faithfully,

C. N. CRESSWELL.

The Right Honourable James Stansfeld, M.P.

Stoke-lodge, Hyde-park-gate, W., May 22nd, 1879.

DEAR MR. CRESSWELL,—Your idea appears to me extremely well worth thrashing out with competent persons.

My feeling is that it is too big for the Society of Arts to take up, without first sounding a few picked men amongst architects, sanitary engineers, surveyors, and builders, resulting, possibly, in a select Conference on the subject.

I am not sanguine, but I think the idea is good, and that it could not but do good to "ventilate" it.

Yours truly,

J. STANSFELD.

CONFERENCE ON NATIONAL WATER SUPPLY, SEWAGE AND HEALTH.

Proceedings of the second day, Friday, May 16th, the Right Hon. James Stansfeld, M.P., in the chair.

The Chairman, in opening the Conference, said the first subject was—"The evils of impurity consequent on the connection of the water supply with sewage."

Dr. Thorne Thorne then read his paper, "The Recent Outbreak of Enteric Fever at Caterham," and also added various other examples, showing the connection of outbreaks of enteric fever with polluted water. He also wished to add a word with regard to what might be supposed to be a special danger attaching to large water services. Of course, when such mischief as he had referred to occurred in connection with large waterworks having large areas of supply, it caused widespread disease; but he was convinced that, for every 100 cases of typhoid fever thus produced, the number resulting from the contamination of shallow wells sunk in filth-sodden soils was a thousandfold. Another important point was, that the mischief resulting in the former cases was so easily capable of remedy, whereas the only remedy in the case of a polluted shallow well was to clean it out, and that was utterly useless when the contamination was washed in from the soil in which it was sunk. He thought that the extensiou of large public works for water supply must be looked on as the most certain means of eradicating an evil which, unfortunately, had hitherto caused, year by year, from 70,000 to 100,000 cases of preventable disease.

Mr. Baldwin Latham, C.E., asked if Dr. Thorne could give any information as to the quality of water taken from this well which was probably mixed with the typhoid poison.

A Member asked how long the elements of disease remained in the water, from the first spread of the disease until it passed away?

Dr. Thorne said he could not satisfactorily answer Mr. Latham's question. Owing to the construction of the adit the water became turbid, and, therefore, it was as much as possible pumped to waste to diminish the turbidity, and thus he was unable to ascertain the extent of dilutiou. There was, however, considerable probability that the extremely mild nature of the disease was due to the enormously diluted state of the poison. It several times happened that mild outbreaks of enteric fever had occurred in connection with a largely diluted state of the poison, but the extent of the dilution he could not say. In the first place, one would have to know the amount of evacuations which found its way into the well water, and this he had no means of ascertaining. The other question was also very obscure, and gave him a great deal of difficulty. He induced the authorities to issue notices, cautioning the people against using the water, and having done that, they naturally came to him again and asked when he would give them leave to use the water. It placed him in a rather difficult position, owing to the imperfect knowledge we have as to the nature of the poison of typhoid fever and the extent to which it would go on developing itself. Circumstances of temperature and humidity, and so on, must have been, to a certaiu extent, favourable to its development in this case, but he could not form any idea as to the limit of infection. When he came to possess all the facts, he had a strong impression that before the notice was issued, the poison had very possibly been pumped out.

Mr. H. Masters said he had understood Dr. Thorne to say that in one case sewage found its way into the water mains by the junction of the iron pipes. Could he give any further iuformation about that?

Dr. Thorne said, in the case referred to—that of Over Darwen—the sewage passed along a stone sewer up to a certain point, and when that came into proximity with the water conduit, an iron pipe was carefully laid across to prevent contamination; but owing to a leakage which had taken place from the stone sewer higher up, a cesspool was formed by the side of the water conduit. The iron pipe itself did not leak, but the sewage escaped at the point of junction between it and the stone sewer.

Dr. Seaton (Nottingham) asked what was the chemical state of the Caterham water with regard to purity?

Dr. Thorne said that was another very difficult question, and he had specially avoided having the water analysed. His own impression was, that you might have taken 100 samples and never found any evidence of specifically diseased matter in it; but in the one hundred and first you might have discovered it. That alone would account for the immunity of a large number of people who were habitually using the water. He did not like to speak on the chemical point, but he did not imagine any chemist would say he could have told whether the poison of typhoid fever was in the water in an infinitesimal quantity. It was very probable that, from beginning to end, the Caterham water would have given very good chemical results.

Dr. Seaton said he fully anticipated that answer. Whenever the question of possible pollution of water with the specific poison of enteric fever was raised, they were frequently met with the insufficient reply that the water yielded good results when analysed.

Mr. Birkett asked if the incrustation of iron pipes, as tending to eause pollution of water, had engaged the attentiou of Dr. Thorne at Caterham. He had had some papers printed, showing the effects of hard and soft water on iron pipes, and he thought that would be found to be the principal cause of disease.

Dr. Thorne said he had understood, from a remark made the previous day, that the suction of foul matter into the mains would be necessary before it could cling to any such incrustation in iron pipes, and so give rise to epidemics.

Mr Birkett said this incrustation would take place even with a constant supply. When there was an intermittent supply of water there was sufficient space for gases to be generated, and the first water which passed through naturally got impregnated with impure gas, and disease resulted.

Dr. Thorne remarked that this presupposed that filth got into the mains and was capable of generating foul gas. At Caterham he did not think it was so, besides which the supply was not intermittent.

Mr. Colebrook (Reading) asked if any surface filtration was practised with the Caterham water, or in any of the other cases mentioned by Dr. Thorne; also, if in his opinion, the contaminating matter could have been removed by that process?

Dr. Thorne said the Caterham water was not filtered. It was, as a rule, subjected to Clarke's process, but, owing to some works then going on, the process was not always carried out. In the Lewes case the water was not filtered, but if it had been it would have made no difference, because the contamination took place after the water was in the mains. He could not speak positively with regard to the other question, but he felt that filtration was, as a rule, at the best mechanical, and they had every reason to believe that the particles which gave rise to enteric fever would not be removed by mechanical filtration.

Captain Douglas Galton, C.B., F.R.S., asked whether the water was subjected to filtration iu the houses.

Dr. Thorne said it was in some instances, and some not.

Dr. Vacher remarked that, in speaking of the cases in

that epidemic being singularly light, Dr. Thorne said he thought that might be due to the poison being received in a very dilute form. He wished to ask if he had any warrant for that belief? The poison being particulate, he believed that when it was very dilute it diminished the chance of a person taking the disease at all; but when he had once received the seeds of this disease, it had then the power to fructify and multiply so much, that probably, if the water was very dilute, and delivered to 100 people, 99 would not have the disease at all, but the one subject who would take it would have it in as bad a form as if he took several germs instead of one.

Dr. Thorne said he could only answer the question very generally, by saying that he believed, in several instances where the dilution of the poison had been obviously very large, the mortality of the epidemic had been extremely small. Taking the Caterham and Guildford cases especially, the mortality was very slight. He was under the impression that if we received into our systems a definite quantity of a growth, capable of developing up to a certain point, the chances were, that if we received ten times that amount, the disease would be much more severe.

The Chairman said he doubted the advisability of entering on a discussion of this purely medical point; they were assembled as sanitarians, not as medical men, and he presumed they were all satisfied that, however diluted the poison might be, it ought to be kept out of the water.

Mr. Lucas asked if Dr. Thorne had ascertained whether the deep borings, put down through the chalk into the lower greensand, yielded any water; and inasmuch as the adit was constructed for the purpose of passing the water into the well out of which the Caterham Company pumped, whether he had ascertained at what date the water from the lower greensand was supplied to the Caterham Company's well. He wished to know whether he had thoroughly sifted the question, so as to satisfy himself that the introduction of this new water had nothing to do with the outbreak of the disease, because he thought the evidence with regard to the evacuations was somewhat weak, and, to say the best of it, he thought it was a case of not proven.

Dr. Thorne said the information he received from the Company was that the lower greensand was reached at a date when the cause of the epidemic had already ceased to be operative.

Mr Ernest Hart then read his paper, "Epidemics produced by Polluted Water Supply."

Mr. Cresswell said he could give a piece of information to the Congress which he thought would be satisfactory. A very important question had been asked of Dr. Thorne, whether he had examined into the chemical condition of the water in the Caterham case—whether, in fact, chemistry could have discovered any trace of infection. He, however, had very wisely abstained from having the matter chemically investigated. As a mere matter of legal procedure, he wished to inform the Congress that the Courts of Law, in the famous case known as the Cockermouth case, had decided that it was not at all necessary to prove the existence of a legal nuisance in the water alleged to be contaminated. It was quite sufficient to prove that there was a potentiality of contamination, that water, in fact, had been allowed to flow from sewers into a river, and chemical demonstration of the existence of pollution at a given point was unnecessary, and necessary to justify an injunction being granted to prevent a violation of sanitary law. Cockermouth drained into a river known as the Derwent, and the people of Workington, eight miles below, complained that they were being poisoned, and sought to restrain the pollution of the river. The argument on the part of Cockermouth was this, prove that we have created a nuisance by the existence of a nuisance at Workington, from whence you draw your water supply. They called in Dr. Frankland, on behalf of Workington, and he stated to the Court that it was impossible to discover, by chemical analysis, any traces of pollution in the water; but he added this very pregnant statement, that he himself was satisfied of the existence of pollution, although it might be impossible by chemical analysis to detect the germs. The Master of the Rolls, whom they knew to be a learned and energetic judge, by no means trammelled by antiquated traditions, decided that, inasmuch as the Legislature had satisfied itself that it was an improper and unjustifiable act to pollute water by sewage, he would not require absolute legal evidence to justify the intervention of the Court.

Dr. Seaton said his object in asking the question of Dr. Thorne had an important bearing on an outbreak of enteric fever, which occurred eight years ago in Radford, a suburb of Nottingham, and which had been investigated by him. The district was partly supplied with water from a well sunk in the bunter beds of the new red sandstone, in a populous part of the town, and which, on chemical analysis, presented very fair results. Nevertheless, the facts pointed strongly to a connection between the water supply and the spread of the disease, and this was the more probable on account of the position of the well and its liability to occasional contamination. Dr. Thorne's conclusions were, that all possible sources of excremental contamination in the vicinity of water sources should be strictly inquired into and rigidly dealt with. In that particular instance the supply of water was in the hands of a private company, and although it was of the utmost consequence that the supply should be investigated in the fullest possible manner, the company objected to giving the opportunity of so doing, on the ground that their own adviser (an eminent chemist) had pronounced the sample he examined to be good. He had himself experienced much difficulty in impressing upon people the importance of not resting content with chemical analysis alone in the matter of water, and the need of looking narrowly to possible causes of excremental contamination, it being necessary to regard all such contaminations as potentially that of enteric fever.

Mr. Lewis Olrick said the Conference met for the purpose of improving the public health, and one would naturally infer that the public would be most interested in the subject, but it was nothing of the sort. He had himself, simply as matter of precaution, adopted means for purifying the water used in his own house. Of course in the cases mentioned by Dr. Thorne, Mr. Hart, and Mr. Latham, no filters in the world would purify the water, but the difficulty might be met by boiling it. Unfortunately, the public would not take the trouble to protect their own health. He did not speak merely of poor persons, but those comfortably off would take great care to provide an ample supply of wines and spirits, but if you asked them to spend £3 or £4 for the purpose of purifying their water, they would not do it. He hoped one result of this Congress would be to teach the public a lesson, that there was an immense danger in not purifying drinking water, and if they did not take heed of the warning they must put up with the consequences.

Mr. Baldwin Latham said they were all much indebted to Dr. Thorne for his very valuable paper, and although this outbreak had been the means of inflicting so much misery on many, yet the lessons to be drawn from it would be of great use in the future. He was prepared to believe that very few outbreaks of typhoid occurred except under the influence of impure water, but he could not quite agree with the conclusions arrived at by Mr. Hart, that there were other modes of impurity by which water might be polluted; he thought

it very doubtful if any aerial impurity could be absorbed which would be the cause of typhoid. If Mr. Hart had carefully considered the case at Croydon with respect to an intermittent supply and the impurities being drawn in, he would have found, from Dr. Buchanan's return, that in 1875, in the months of June and July, when there was the greatest demand for water, and the greatest intermittency in consequence of not being able to supply the demand, they were the two months freest from fever. Again, with regard to the 1875 outbreak in the Friends' School at Croydon, the boys' wards were supplied direct from the mains, but the girls were supplied through the intervention of an open cistern in the roof. There was a great outbreak of fever on the boys' side, but not a single case on the girls' side. There the intervention of a cistern seemed to have been a preventive. The late Dr. Letheby carefully inquired into that outbreak, and recommended the authorities to introduce similar fittings into the boys' side of the school. Again, in 1875 alone, there were something like 1,400 cases of fever in Croydon, and the whole of the dejecta from those patients was passed into the sewers and then on to the irrigation farm. Between the irrigation farm and the River Wandle was situated the very populous district in Wallington, which drew its water supply from wells, so that they got little or nothing but the percolation of this sewage farm; yet it was a singular fact that, in 1875, there was not a single case of enteric fever in any part of the district. There you could trace the underground water on to the farm and through wells down to the River Wandle, and yet, under those conditions, it showed that the effects of exposure of the water, as in irrigation, entirely destroyed the poison of this particular disease. He had charge of the whole of the district for sewerage purposes for some miles round the Croydon Irrigation Works, and the sanitary authority had been most anxious as to the health of this district. For many years past it had been found that the whole of the valley of the River Wandle, starting from Croydon Sewage Farm, and passing down to Wandsworth, was remarkably free from enteric fever. It was asceraince by measurement of the wells in that district that they never fluctuated, the soil was rather porous, and there were 36 mills on the River Wandle, which dammed up the water, so that the water level of the subsoil varied but an inch or two from one year's end to another. That meant that the subsoil must always have in it a certain amount of water, and there you came to the question of dilution. Since 1875, although there had been no intermittent water supply whatever in Croydon, yet the amount of fever was not got rid of. The conditions were these. The moment the water got to a remarkably low level, on the very first instance of the rise an outbreak of fever occurred; and from having himself made four or five experimental wells, where he had now had for two years self-recording apparatus at work, recording every fluctuation in the subsoil water, he could show that it was due to the fact that when the springs got to the very lowest they began to fill up in the lower parts of the districts before they did in the upper portion, and consequently surface impurities were carried down when the springs were low, just at the time the springs again began to rise. That was corroborative of the results obtained in Germany by Professor Pettenkofer, who showed that enteric fever, and even cholera, was always coincident with the lowest levels of subsoil water. It was true that the greatest outbreaks of fever always occurred after the driest periods. Dry years were invariably fever years. If we were now to have a long dry period, very shortly after the first shower of rain in most of the villages supplied by local wells, there would probably be outbreaks of enteric fever. He had a strong impression that the influence of light had a powerful effect in destroying whatever might be the poison of enteric fever and some other diseases. Pollution under the conditions of darkness, such as getting directly into the water mains, as happened some years ago at Ely, or into the ground water, was the most dangerous. There were a great many cases which all showed that underground contamination was far more dangerous than above ground. A well known case was that in the first cholera outbreak, where it was shown that at Wolverhampton the place was so attacked that the people actually camped outside the town, the sewage all passed into the River Tame, which flowed down an open channel for several miles, and the water was pumped for the supply of Birmingham; yet there was only one case of cholera in Birmingham, and that was reported to be an infected case. It did not matter whether they had to deal with germs or specific poisons, so long as it was known what the conditions were which caused disease, and it all came back to the question of fæcal pollution of water. Guard the water from pollution, and you were safe from many diseases.

Mr. Alcock said there was no doubt a deficiency in the powers of sanitary authorities, in some cases, as was shown in the case mentioned by Dr. Seaton, where the supply of water from a deep well was apparently pure, and being in the hands of a private company, they objected to its being inquired into, because they had a report from their own chemist that it was pure. It was this difficulty he wished to draw attention to. When the supply was in the hands of a private company, how were the sanitary authorities able to deal with it, when, as in that case, the water might be chemically pure, and yet the sanitary authority might be perfectly satisfied that it was polluted from sewage, or other deleterious matter? In the neighbourhood of Sutherland, where the water supply was certainly pure, and for drinking purposes admirable, they had found very great difficulties in many ways; first, in enforcing the supply of water, and, next, in consequence of its being entirely in the hands of a company, of detecting impurities should they exist. One of the first necessities in connection with water supply was, that it should be taken out of the hands of private companies, and vested in sanitary authorities, who otherwise were almost powerless, unless they could show by chemical analysis that the water was impure. It was very difficult to trace the impurities, and having traced them probably to their own satisfaction, it would be very much more difficult to enforce any improvement upon a private company. Many sanitary authorities would like to obtain power to transfer the water supply to their own hands, but when they had the experience of the Stockton and Middlesboro' Bill, which only passed a session or two ago, and the frightful expense it entailed to enter into a Parliamentary contest with a private company, they might well shrink, as they did at Sunderland, from such a course, although they would be most happy to take over the water supply, paying the shareholders a liberal compensation for their property.

Dr. Thorne regretted that he had not made fuller reference to the action of the Caterham Water Company, because, although he fully agreed with the last speaker in many points, he thought the difficulties experienced in dealing with private companies were certainly not universal. The moment he suggested to the Caterham Water Company there was a possibility that their water was producing mischief, they told him that every information and assistance by their staff was absolutely at his disposal, and the Chairman himself not only helped him officially, but told off one of his engineering clerks to go with him and work up the subject. In fact, without the company's help, he should have had great difficulty in dealing with the special immunity of Warlingham. The company also adopted every single recommendation he could suggest, after ascertaining the cause of the epidemic; the wells were saturated with a strong solution of chloride of lime,

and they pumped the water to waste for about three weeks, in order to get rid of all water which could have been contaminated.

Mr. Mackinnon said it was impossible to overrate the importance of the paper they had heard that morning, and he could support the conclusions arrived at by his own experience of many years in Monte Video. The houses there were all flat-roofed; the rain-water was collected from those house-tops, and carried by pipes to a reservoir under the pavement in the centre of the courtyard. As they all knew, cats were very fond of taking the air on the house-tops, and consequently there was a rapid accumulation of their excreta which was carried down with the rain to these wells. The water was also contaminated from the cesspools, which were attached to each house; and, as they knew, human urine had a powerful effect in dissolving lime and cement, and consequently these liquids very easily found their way into the reservoirs. He was Director-General of Public Works, but had never found one reservoir where the water was not contaminated. The result was, that diseases were very rife. A system of sewage had been carried out, and also a supply of water by a company, but the public were very loth to take advantage of these appliances until a very severe outbreak of cholera, yellow fever, and typhoid made them think whether they had been doing right. He hoped the time would come when the Government of Uraguay would insist on every inhabitant connecting his drains with the sewers, and consuming water supplied by the company, and ordering the closing up of each reservoir and cesspool attached to each house.

Dr. Ward said that very often medical officers in the country had opportunities of pursuing investigations into the causes of diseases which those in towns had not. In the district it had been his privilege to administer for the last few months, there had been peculiar facilities for studying typhoid fever. His district was in West Cumberland, commencing with Keswick, and going down to the seaboard. There were very few cases at Keswick where they had pure water; at Cockermouth there were more cases where the water was river water, and, to some extent, contaminated with land drainage. At Workington, during the last winter there had been 50 or 60 cases of typhoid, some very severe, but others milder. The intensity of the fever was not altogether owing to the impurity of the water, but also to the contamination of the house atmosphere from sewer gas. He had investigated many cases, and always found that where they were most severe, there had been sewer gas present in the house. He would not say that this was an exciting cause, but it was certainly a predisposing cause of typhoid fever, which was apt to be overlooked. The conclusion he came to was that impure air was not only largely the cause of zymotic diseases, but also of a large amount of local diseases, such as inflammation of the lungs, and of the brain, which he had clearly traced to the pollution of the atmosphere.

Mr. Maxwell said the lessons they were daily getting on minute contamination could hardly be too strongly impressed on the public mind, and what had been heard that morning would go very far to do away with the idea that a chemical analysis was at all times a test of pure water. The question of constant supply was one which ought to be considered in reference to these particular contaminations, and he had no doubt that contamination did get into the pipes by an intermittent supply, as when it was cut off daily, which was the practice in London, or when the pipe-layers were at work in the streets. As a rule, all taps were left open for the supply to come on again, and the consequence was, there was a natural suction into a great many of them, which absorbed the air from the vicinity. In the case of water-closets this had a very detrimental influence, because many of those closets were still constructed with the water service communicating direct to the soil-pan. It ought to be a rule that no water-closet should be constructed without the supply being taken from a separate cistern. He was much struck with the remarks of Mr. Latham about exposure to air and light. He was connected with works where the supply was from artesian wells, and some people wanted them to pump direct from the wells without the intervention of any reservoir. That they could not do, because the well did not yield sufficient during the day for the supply, and they were compelled to store a certain quantity; but the question was often asked—Was the water injured or not by being brought up from the chalk and exposed to the light. His own impression was, it was not; but it was a point upon which he should be glad to have further information.

The Mayor of Oldham (Mr. Hamilton) said he had listened to the various speakers with very great interest and profit to himself. He might point out that there was one source of contamination which had not yet been touched upon, but which was very general throughout the agricultural districts. In all large farms it was usual to have what was called a straw-yard, where cattle were impounded day and night, and their excreta was collected generally for twelve months, when it was cleared, out and fresh straw put down for the ensuing year. Almost in every case the straw-yard extended near the farm house kitchen door, and the well for the supply of the house and farm-yard was between the two, a portion of the liquid manure thus found its way into the well, and there could be no doubt an immense deal of contamination occurred. He was a frequent visitor to many of our largest agricultural counties, and after hearing what he had that day respecting impure water being the sole cause of typhoid fever, he must say he was thankful he was still alive. He quite agreed with those who affirmed that a good and pure supply of water could be found above and under ground upon nearly all the farms in England, and he was certain that every rural parish could find within itself good and pure water sufficient for its requirements. He trusted that at next year's Conference a paper would be produced on this subject.

Mr. S. W. North (York) wished to ask Dr. Thorne if there was any evidence, and if any what, of the multiplication of the elements of typhoid fever outside the body. There was no doubt that infected material conveyed the disease to others, but there was the greatest difficulty in persuading the general public, and even sanitary authorities, that 2 or 3 ozs. of infected material poured into many million gallons of water, could propagate the disease amongst the general inhabitants using the water. He thought himself that sanitary authorities and the general public were to some extent right, and that, if typhoid fever were propagated by such minute infections of water, we should none of us escape. He could only say he should scarcely dare taste water again if he thought such a thing probable, because he could not see how you could get water which might not be more or less contaminated in that way. In saying this, he said it with the full conviction that, in tracing the origin of typhoid fever to the contamination of water in some way, we had got on the right track; all he wanted to say was, that they should not commit themselves to any conclusions which were not ascertained facts. There was in the general public, although not well informed, a pretty strong logical mind, and there was considerable difficulty in persuading them that these very minute causes had the widely operative influences which some sanitary authorities supposed. He, therefore, wished to ask Dr. Thorne the question he had stated.

Dr. Thorne said a complete answer to the question involved such an immense amount of information that he hardly liked to enter upon it. He did not feel himself capable of doing it safely from a pathological point of

view, but the facts certainly bore out the view he had expressed, and not only so, but there was ample proof that minute quantities of poison had produced these results. For instance, take the Lewes outbreak; it was clearly due to minute particles of typhoid excreta which were drawn from certainly not more than a dozen closet pans in that town into the mains. Whilst those particles were being drawn into the mains, the disease was rapidly progressing, and the moment a constant service was put on, which prevented that suction from taking place, the disease stopped.

Mr. S. W. North said he did not dispute the general inference from the published information, and he would save the time of the Conference. He wished to confine himself to the question whether there was any evidence of multiplication of disease germs outside the body.

Dr. Thorne said that in an allied disease the specific germs had been isolated, but he had never seen a typhoid germ, and therefore could not say there was any visible evidence. He knew himself there were such specific germs, but he did not think he could prove it to any one, apart from the general inference to be drawn from epidemics.

Mr. Ernest Hart, moved the following resolution:—"That since a comparatively minute quantity of the poison contained in the evacuations of the patients of enteric fever may, it is believed, when subjected to conditions favourable to the development of that poison, lead to the specific infection of very large volumes of water to which it has gained access, all sources of excremental contamination in the vicinity of water sources should be rigidly dealt with during their construction or repair, and in their use." He thought the information contained in Dr. Thorne's paper, and his own abstracts, would amply justify the Conference in passing such a resolution. It might, of course, be open to doubt, and it was open to further research, whether, and in what way, the specific poison of typhoid fever multiplied out of the body. That was a question of minute pathological investigation, which was open to this preliminary difficulty, that, as Dr. Thorne had said, they had not yet isolated the particulate contagium of typhoid fever in such a manner as to be able to experiment with it by culture. On the other hand, all the facts, irrespective of any pathological theory, pointed irresistably to that conclusion. It had proved, as a matter of fact, that a particular source of water supply being infected. an enormous number of persons had suffered from typhoid fever so infiltrated. Not only were there now stated a number of facts which most minutely investigated, bore that interpretation, but they also found another kind of facts, that by cutting off the source of contagion you immediately arrested the epidemic, and you might predict with certainty that if at any moment such contagium did pass into water, a large number of people would be so poisoned. He remembered very well in the last cholera epidemic, which occurred in the East-end of London—which was a sudden explosion, so to speak—he then said to Mr. J. N. Radcliffe, who had since become a Government inspector, that all analogy pointed to the fact that an outbreak of this sort must be caused by contamination of the local water supply, and he commissioned him to make an inquiry. All the facts appeared to be against it; but Mr. Radcliffe, following out the various clues, traced it to the East London Waterworks, and it was found that on a particular day the East London Company had used the water from a particular reservoir, and the water in that reservoir had been contaminated by the excreta of a person who had come to Southampton with the cholera, and had come from there to the River Lea, and that the one individual had brought Asiatic cholera to the banks of the Lea, and the dejecta of that one person sufficed to cause the last and most severe limited outbreak of cholera in this country—he trusted he might say, owing to the information now obtained, the last outbreak which ever would occur in this country—because he did believe that, in consequence of the precise manner in which enteric fever and cholera had now been traced to polluted water, by adopting such precautions as the resolution pointed to, they might prevent any outbreak of Asiatic cholera in an epidemic form, and also prevent the sporadic, endemic, or epidemic outbreaks, of enteric fever.

Mr. Cresswell seconded the resolution. The first reason why he supported it was, that it would enable them directly, or indirectly, to get rid of a nuisance throughont the country, which was universally accepted and acknowledged, namely, the intermarriage of the domestic well with the domestic cesspool. His second reason was, that he believed a resolution going forth from that Congress of intellectual and scientific men collected from all parts of England—representative men—would strengthen the hands of all local authorities throughout the kingdom, and enable them to carry out the provisions of the law which already existed with reference to the pollution of water; and if they found by experience, as many had done, that those provisions were inadequate, would enable them to go to the Government and demand the reform which they believed to be necessary.

Mr. Adams (Maidstone) thought it would not be right to pass altogether unnoticed some remarks made by Dr. Thorne with regard to chemical analysis, which, if they had their full effect, would do damage to the cause of chemistry, and ignore the assistance which might often be obtained by that science. He was quite sure that Dr. Thorne would agree with him that, in many cases, chemical analysis was useful. A very small amount of the potent animal influence, disease, germ, or whatever it might be called, might exist in comparatively pure water which came from a public company, and might not be traceable by any means at the chemist's disposal. On the other hand, in country districts where almost every person had his private well in connection, or closely allied with the cesspits, the evidence which could be got by the chemist was very much more obvious and tangible. Perhaps he might have no means of detecting and isolating the germ of disease in sewage, but it was by its associates generally that they could, as chemists, track it out; in nine cases out of ten disease germs would have those associates, and by the discovery of those an alarm note might be struck, and hence chemistry would be valuable. Therefore, he ventured to enter a quiet protest against Dr. Thorne's remarks being taken to signify more than he would wish them to in throwing any doubt on the important results oftentimes obtained by chemical analysis.

Dr. Thorne said he entirely agreed with what had fallen from Mr. Adams. His remarks applied solely to the Caterham water.

Mr. Birkett said he had not the good fortune to be a scientific man, but he was sure that very few had given greater consideration to this subject than he had. The pollution of water was the most fruitful source of disease. The contamination of dwellings from sewer-gas was also a direct cause of disease, and he wished to draw attention specially to the great evil which existed in large towns like Manchester and Liverpool, where the area of the household was so limited that it was absolutely impossible for the inhabitants to breathe pure air. When each individual imbibed about two and a half hogsheads of impure air each day, it was easy to conceive what the effect must be on the system. Therefore, whilst attacking the pollution of water and defective sanitary arrangements as going to the very root of the evil, he also thought there should be legislative enactments which should prevent builders or land owners putting up houses with rooms of less than a certain size, and on a sufficiently large area to allow of thorough ventilation.

Mr. Colbrook said he had previously asked whether filtration would remove poisonous germs from sewage, and the reply was that it was doubtful. He wished, further, to know what would be the effect if the excreta of infected patients in towns were taken to a sewage farm and percolated through the land—would the germs be thereby destroyed? or would the effluent water convey germs to the river from which towns lower down would take their supply.

Mr. Ernest Hart said there was a vast amount of scientific evidence which would satisfy the mind of any layman; he believed that the theory that this poison did, and could, multiply itself almost indefinitely, was true. He referred more especially to the most recent researches of M. Pasteur on charbon and the splenic disease of cattle. The smallest quantity of blood taken from an animal dying of this disease would communicate the particulate poison, which there was great reason for comparing with the particulate poison of the typhoid disease. Pasteur showed that a single drop of blood of an animal affected with splenic disease might be inoculated in a culture-fluid, and produce an indefinite multiplication of that particular poison; that a drop taken from that culture-fluid passing on to another would produce similar matter in the second, and so it might go on almost indefinitely, and a single drop taken from any of these cultured fluids, and, therefore, indefinitely diluted, if it were a mere mechanical dilution, would prove intensely poisonous to the last series of animals, and would excite the same disease with absolute certainty. Similar evidence had been obtained as to the poison of septicæmia, or blood-poisoning. Therefore, there was evidence apart from absolute facts, that a particulate poison like that of typhoid, might, and did, out of the body indefinitely multiply itself. As to filtration, there was no doubt it had a very great influence, and especially filtration through the ground, and through ground filled with the rootlets of growing plants in destroying typhoid poison, but it could not be absolutely relied on. As Mr. Latham had pointed out, these germs fertilised and multiplied much more readily in darkness. Some attempts had been made to reduce almost to a matter of measurement the bulk of water, the amount of air, and the quantity of light necessary to destroy these germs, but it was perfectly well known that all flowing streams tended to purify themselves, that if you oxidise any of these ferments, which were organic ferments of low structure, you practically disintegrated them, and filtration through the earth into a river which then flowed exposed to light and oxygen were conditions which tended to destroy the poison. Still, you could not depend on them absolutely, because there might be fissures in the land, and instead of filtering, the poison might pass through the fissure, and be taken direct into the stream. Therefore, the rule should be universal, that wherever typhoid excreta were known to be such, they should be disinfected or burned before being buried, because one of the very last cases he had occasion to investigate of typhoid, was a case in which the excreta of one patient had been buried in accordance with what was believed to be sanitary rules, but having been buried in gravel, it found its way into a well some 30 yards below, and gave rise to an epidemic. The rule should be to take the precautions referred to in the resolutions, and, in addition to that, wherever typhoid excreta were known to exist, to have them destroyed.

The Chairman said if he did not think the resolution was of a practical rather than of a medical character, he should not be disposed to put it to the meeting. As far as he was concerned, he had no difficulty in accepting the views propounded by Dr. Thorne and Mr. Hart, but he might accept views and yet not feel entitled to record an opinion upon them; and on medical and scientific questions of this kind he preferred to take this position—to base himself on the inquiries and opinions o the highest authorities on the subject; but doing that he did not wish even then to carry the matter too far, but to limit the expression of his opinion a little further, and to say that he wanted some practical view which addressed itself to his own mind, and upon which he could feel himself entitled to exercise a judgment before pronouncing an opinion. In this case he was not prepared to pronounce an opinion on the scientific question raised by Mr. North; but, in the papers of Dr. Thorne and Mr. Hart, and in the experience and knowledge of the gentlemen present, there were ample reasons to entitle them to express this conclusion, that a comparatively minute quantity of the poison contained in the evacuations of patients of a certain kind, when subjected to conditions favourable to its development, might lead to the infection of large volumes of water. They had ample evidence to justify that proposition, and the practical conclusion to which the resolution led was one about which there could be no difference of opinion.

The resolution was then carried unanimously, and the Conference adjourned for luncheon.

On re-assembling,

Mr. Sillar said he should have liked to have addressed the meeting, more especially in connection with the town of Aylesbury, and the sewage work there, but it had been frequently described before, and it was not necessary to repeat it. He said that, some years ago, the great difficulty towns had to encounter, was that there were no known means of economically dealing with this great question, but now many ideas had been started and experimentally tried, and it was admitted that there were several good plans for getting rid of sewage, so that the difficulty rather lay in the choice. He was not going to say one word in favour of the Aylesbury process, as it was well known, and had been visited by thousands of people, and he had never heard anything but satisfaction expressed at what was seen. The objection which seemed to be generally started was as to the cost, and as to that he preferred to say nothing; because, whenever people were pecuniarily interested in any process, their words were received with great caution; therefore, he should prefer people making their own inquiries. He would rather speak on the general question of sewage precipitation and treatment. This question had been left to private enterprise. Whether it was right or wrong that this should be done was perhaps open to doubt; but so long as it was left to private enterprise, it must be done from some hope of reward. Patent rights were limited to a certain number of years, which soon passed away, and unless towns had some outside pressure put upon them to justify them in increasing expense, they much preferred the path of inaction. Delay was what they liked, and he could quite enter into the feelings of gentlemen who had charge of the expenditure of money for towns, for it was a most unpopular thing to engage in any expenditure necessitating the levying of rates, unless they were really compelled to do it. There seemed to be no compulsion exercised, because the excuse was so plausible: "we really do not know what to do." The Native Guano Company, which he represented, had done its part in the work, and he believed they had solved every practical difficulty. The works were open to the inspection of anybody, and there were gentlemen present who had seen them, and could testify that the effluent water was practically innocuous; that there was no offence whatever about the process; that the manure so made had a very high agricultural value; and that it could be done at a comparatively moderate cost. At present there was a great depression in agricultural industry, and one of the principal reasons why this was not more taken up was that the farmers had not money to spend in manures. In fact, the land was suffering from the poverty of agriculturists. The result of an experiment he had made with this sewage manure was that one seed of oats planted by himself with the

manure produced in the autumn upwards of 7,000 grains. This showed that the deposit, preserved from sewage without using those elements which destroyed the manure, had a very high agricultural value, and he believed that the value consisted in this, that it was the natural manure for the ground. On this principle, it had been recommended that it should be tried on the continent, where people suffered so much from disease of the vine, and he had the satisfaction of seeing in the *Times*, a few weeks ago, a statement that for the first time in history the ravages of the *phylloxera* had been suspended by the use of manure, the basis of which was manure produced at Aylesbury. He believed the agriculture of England would be benefited when a little more pressure was put on towns to do something, and when they were taught that however expensive it was to purify the sewage, it would be still more expensive not to do so.

Sir Henry Cole briefly stated the substance of his paper, "Progress with Sewage since the first Congress of the Society of Arts in 1876, submitted to the fourth Congress, in 1879."

Mr. Cresswell also stated the substance of his paper, "The Thames and its Tributaries," and concluded by proposing the following resolution:—

"That this Conference recommends the Council to arrange that a Deputation of Peers and Members of the House of Commons, with Members of the Society, may wait upon the First Lord of the Treasury, the Home Secretary, and President of the Local Government Board, in order to urge the necessity of purifying the Thames from sewage without further delay, especially in the metropolis; and to request the Government to bring in a Bill to charge the Thames Conservancy Board with doing the work, and obtaining the funds through the Metropolitan Board of Works, according to the precedent of the action of the School Board for Public Elementary Education."

Sir Henry Cole seconded the resolution. He thought the Metropolitan Board of Works was in this matter the greatest sinner. The sooner they could make use of the Thames Conservancy Board to do the work, and get rid of the pollution of the Thames, the better for the health of London.

The Chairman pointed out the difficulty which occurred to him in point of form. The proposal was to request the Government to bring in a Bill charging the Thames Conservancy Board with the duty of purifying the Thames from sewage without further delay, especially in and near the metropolis, but, as he read the resolution, including the whole of the Thames. It then went on to say that the Thames Conservancy Board were to obtain the funds from the Metropolitan Board of Works. Now, they could hardly be expected to pay for purifying the whole course of the River Thames.

Mr. Rawlinson, C.B., said it would be very difficult for him, as a Government official, to say much on this question. He had listened with great interest to the remarks which had been made, and he did not know that he had any objection to make to anything which had been said. The subject had been put forward in a very interesting and somewhat amusing form, but of course he could not tell tales out of school, or open up all the reasons why the Local Government Board did, or did not do, certain things. It must be self-evident, when the matter was calmly considered, that where there were a multiplicity of inventions for the purpose of dealing with sewage, the Local Government Board, if it took up any one of these schemes and advocated its application would offend the promoters of all the others; but it was not true to say that the Government had not done anything. It had done a very great deal. It had established a Royal Commission, and he saw before him Professor Way, who was his colleague on that Commission, and he would say, no doubt, if appealed to, that he worked most earnestly with his colleagues at that question, how best to deal with sewage, for eight years. They examined all the processes known at that time, visited most of the places where sewage was attempted to be dealt with, and analyses were made, not by ones or twos, but by hundreds; and one member of the Commission, in the most liberal manner, out of his own pocket expended not less than £2,000 to facilitate the experiments of that Commission. Since then there had been great progress, and the Acts had been amended. Sir Henry Cole had stated that there was one dictatorial crotchet for all sorts of cases, and that was that the inspectors of the Board drove every district to purchase land. He did not know how far that was so, but they (the inspectors) certainly had no authority from the Board to do so. One thing he was bound to say, that as far as they were informed by chemists, precipitation of any kind did not give an effluent that could be called pure. Assuming it precipitated some of the salts of sewage, the effluent took away certain of the salts of the precipitants which were put in, and, therefore, there was practically an impure water; either it might be injurious or not, he was not prepared to say, but he would state this, that there were various chemical and precipitating processes which had been in operation now for several years, against which, as far as his knowledge went, there had been no complaint, either from resident owners or riparian proprietors, as to the character of the effluent. That should be taken into serious consideration, and it might be a question as to whether, although an effluent was not chemically pure, the patentees or towns who chose to treat the sewage in that way should not be permitted to do so; for, in the eyes of the law, they were, and must remain, responsible for any pollution that might occur below them. He thought it would be most monstrous if the Government made a hard and fast rule, and declared that in all cases land and broad irrigation alone should be used. With regard to the towns below the intake of the water on the Thames, he expressed the opinion that, if towns below the intake of the metropolitan water companies would precipitate according to the best processes, he did not conceive that the Thames would be injured by the clarified water going in. If the Metropolitan Board were, as most unquestionably they were, under the obligation to precipitate and to clarify the whole volume of sewage now taken in its crude state into the Thames, they would be doing no more than the duty that Parliament imposed upon them and others. And even though it would cost £100,000 or £200,000 per annum, that should not stand in the way of its being done. They had arrived at this point, that, with regard to the dealing with sewage, it was absolutely impossible for scores of towns to acquire the land necessary to purify it by broad irrigation. Again, all through Lancashire, Yorkshire, and other manufacturing districts generally, it would simply destroy the trade to compel them to take their polluted water away and filter it through land at a distance. The water they must have dirty or clean; as the life of their trade depended upon it; it was that which produced the income, and it must be treated on the spot. There had been a great bugbear raised with regard to the pollution of rivers, as if that was the greatest possible crime, and a thing not to be tolerated under any circumstances. He could only say that there were two sides to that question. Taking the West Riding of Yorkshire, where the woollen and worsted trades were now situated, the value of that trade in the year, Professor Way and himself reported, might be shown by the fact that the gross sum expended per annum in those trades amounted to £75,000,000 sterling. Comparing that with the rent of land, it sank into insignificance. Assuming that there was some injury done in polluting these streams by that trade, and that they never could hope to get them back into a pure state, he still made

the assertion broadly that, bad as the rivers were polluted, when a detailed examination was made by the medical officer of the district, if the waters of those rivers were not used for domestic and drinking purposes, they were very little injurious to the health of human beings. A polluted river was not necessarily a health-destroying river. There were probably no rivers so polluted as those which traversed Manchester, but they had a house-to-house detailed examination, and returns of the local mortalities, and though he did not mean to say that these polluted rivers did not effect some injury, singularly enough, the mortality on the margin of those rivers was much less than in streets further away, where there were a superior class of houses, but where there were cesspits more crowded together, and there was less space for ventilation. He did not mean to say that these rivers should be left as they were, but the greatest obstruction and pollution from manufacturing was not so much the chemical ingredients as the mechanical refuse thrown into the bed of the stream. Many of the fluids passing from a manufactory, apparently deleterious, were really purifiers, and it would be a bad day for Lancashire, Yorkshire, and other places where manufactures were carried on, if the fluids from dying and bleaching works were prevented going into the stream until something was done to keep excreta entirely out.

Captain Douglas Galton said he should like to supplement somewhat the history of the pollution of the Thames, so ably described by Mr. Cresswell. The Metropolitan Board of Works was created in 1855 for the purpose of purifying the Thames, and sewering London. That duty was laid down in the Act constituting the Board. They were told to draw up a scheme for relieving London of its sewage, and for placing its outfall beyond the limits of the metropolitan district, the plan to be subject to the approval of the Government. Mr. Frank Foster drew up a plan, and, when he died, Sir Joseph Bazalgette succeeded him. The plan was submitted to Sir Benjamin Hall, the First Commissioner of Works, who appointed three gentlemen to report upon the scheme, Mr. Simpson, President of the Institute of Civil Engineers, Mr. Blackwell, C.E., and himself, of whom he was the only survivor. They examined most carefully into the plan, and suggested some alterations in the capacity and the details of the sewers, the object of which was to prevent the flooding of low-lying districts, which they anticipated, and reported that the outfalls at Barking and Crossness were certain to cause deposits of mud in the channel, and to prove injurious to the sanitary condition of the river. After long inquiry, they recommended that the sewage should be carried to a point in the river about four miles below Gravesend, and there turned into the river, where it was above a mile wide, in very deep water, and where the inflowing tide comes in upon the south side and the outflowing tide goes out on the north side, and they suggested that the outfall of the sewage should be placed at that point. They further suggested that by means of a channel, constructed on the principle of utilising the rise and fall of the tide, the sewage from 91 square miles of the metropolitan area, out of 118 square miles, the total area, might be carried to Sea Reach by gravitation, without any pumping, leaving the sewage of 27 square miles only to be pumped, whereas the scheme of the Board required the sewage from 93 square miles of the metropolitan area to be pumped, some of it twice over, and removed the sewage from 25 miles only to Barking by gravitation. They showed that the capitalised cost of the pumping under their scheme, and of the sewer required, would be less by several millions than the capitalised cost of the pumping done by the Metropolitan Board of Works and of their sewers. This report was referred to the Metropolitan Board by Sir Benjamin Hall, and discussions were taking place upon it, when the then Government went out. A new Government came in—Lord John Mannners succeeded Sir Benjamin Hall—he probably did not like the responsibility of the decision, and, therefore, introduced an Act of Parliament which relieved the Government from the necessity of approving of the plans of the Metropolitan Board, and they were left to do as they liked. We now saw the result. It would be quite possible to carry the sewage down to Sea Reach, but we could not now, without an enormous reconstruction of the sewers in London, carry down there by gravitation the quantity which might have been carried had the scheme of the referees been adopted in the first instance. He believed, however, that it would still be a more economical plan to carry the sewage to Sea Reach than to spend £100,000 or £200,000 a year in clarifying it. The referees further suggested that, where there were outlying districts around London not included in the Metropolitan Board of Works districts, there should be some arrangement by which the sewage of those places should be brought to the outfall at Sea Reach into connection with that of the metropolis, because the referees saw the very great difficulty which must arise, in towns like Richmond above London, and again in towns beyond the metropolitan boundary below London, if they were to be obliged to devise independent schemes of sewage. The only point in which he differed from the resolution was with regard to relieving the Metropolitan Board of Works from the duty. Because, notwithstanding they had not fully performed the duty of placing the sewage where it would not pollute the river in the metropolis, still they had done an enormous deal in London; their works had been carried out remarkably well; their embankment was very good, and the sewers were admirably constructed; and he was quite certain that Sir Joseph Bazalgette would be competent and prepared to carry out any scheme he was ordered to do by the Metropolitan Board. He, therefore, thought the duty should rest entirely upon them to complete the fulfilling of the conditions of their original Act of Parliament.

The Chairman said he still had some objections to the form of the resolution. Although one objection he made had been remedied, two other objections still occurred to him. He thought the resolution was too vague in its statement of the evil to be remedied. The proposal was to purify the Thames without delay, but if they passed a resolution of this kind, meant to be directed against the non-fulfilment of their duties by the Metropolitan Board of Works, it ought to specify the respect in which they had failed. Then the conclusion was that they should ask the Government to charge the Thames Conservancy Board with the doing of this work, taking it out of the power of the Metropolitan Board, but making that Board raise the money for the operations of another body. Now, whatever they might think of the shortcomings of the Metropolitan Board, it did strike him as very useless to go to the Government and ask it to transfer the power from the properly-constructed authority in the metropolitan area, and to give their business to another Board, and still make them pay for it. He, therefore, thought the resolution wanted a further modification, and if they thought it necessary to draw public attention to the failure in their duties of the Metropolitan Board, that failure should be specified, and the Board itself should be called upon to remedy the failure.

Mr. Chadwick, C.B., perfectly agreed with the tenour of the Chairman's objection. Whatever resolution was passed should, he thought, be subject to consideration and discussion in the Council, for there were a great many objections to each of the points which might be heard in the Council, but which would be too long to discuss there. He could occupy an hour or so upon one or two of them. The great point was to have the charge that the Metropolitan Board had failed in its duty fairly determined. That at present, was somewhat *sub judice* between them and the Thames Conservators, who alleged

that they had failed, and that what they ought to do was to prosecute that settlement. It was quite clear that they had utterly failed, for they had expended some four and a-half millions of money to purify the Thames, and had utterly failed to do so, although by other methods, of which they had now practical examples in different parts of the country, half the sum of money spent would have accomplished the object. Instead of sending the whole mass of sewage over 11 miles down the river to one point, the antecedent plan which he had proposed was, by sewers and pumping power, to radiate it out in the direction of demand, or as facilities might occur for disposing of it. A German engineer who had charge of a river in similar conditions to those of the Thames, and who came over here to inspect the metropolitan plan, rejected that plan, and went back to the system of radiating out the sewage in the direction of demand. That was now in progress in Berlin under impartial, and, he hoped, competent skilful treatment. He doubted if the Metropolitan Board was large enough to carry out this enormous task, and thought it would have to be reconstituted. On this ground, he saw considerable difficulties in the way of the resolution as it stood, and thought it would be better if it were simply confined to a statement of the fact that, according to all accounts, the Metropolitan Board of Works had failed in effecting its object, notwithstanding the enormous expenditure, and that that failure ought to be the subject of inquiry by a select committee in Parliament or otherwise.

Mr. Cresswell said that havimg received such an intimation from the Chairman, he would most willingly yield to the invitation given, but he felt he had no right to do so without the consent of the meeting.

Mr. James Wylde remarked that he could fully confirm, from personal observation, the truth of Mr. Cresswell's statements in respect to the Thames. Last year he had made, on frequent occasions, between April and August, careful examination of the river from Richmond to Gravesend, and had never seen it, during the last 20 years, in a worse condition than during July and August of 1878. The soluble and suspended matters were very great, and at a temperature of 80° to 84° Fahr, the stench, in the months last named, was sickening. Mr. Wylde added that he had accompanied the Metropolitan Board during their trips to Gravesend in November. The results were negative, but this was easily accounted for. Heavy floods had preceded the date of these trips, and they were undertaken when the air-temperature, on each day, did not exceed from 32° to 38° Fahr. Under such circumstances, of course, it was scarcely possible that the river could be offensive, as the filthiest ditch would then cease to be so.

Mr. Birkett said he should heartily support the resolution if it were so enlarged as to include all Conservancy Boards, because it was not only the Thames Conservancy Board, but Boards throughout the kingdom, which had similar work to perform. He thought it would be also well to leave it a question as to who was to pay the expense. The tendency of the discussion seemed rather to be in the direction of legislation in these matters which he thought was a mistake. The duty of the Society was to find out the evil, and then the suggestion would go with such weight to the Legislature or Government, that it would be received with some consideration.

The Chairman said the proposer and seconder of the resolution now proposed to change the form to the following:—"That this Conference recommends the Council to arrange that a deputation wait upon the Government to urge the necessity of taking further legislative means to prevent a continuance of the pollution of the Thames by sewage." If no one else had any remarks to make he would put it to the meeting.

The resolution was carried unanimously.

Mr. Chadwick then stated the substance of his paper, "Course of Inquiry as to Works of Sanitation, and as to their expense and results." He also suggested that in all places where the death-rate had not been decreased, special investigation should be made to ascertain why it had not done so. He maintained that for every £1 per house wisely expended on sanitary works, the death-rate ought to be reduced by one per 1,000.

Mr. Chadwick further stated, in respect to the course of examination displayed in the paper on the works at Croydon and Bedford, and undertaken for the information of the Belgian Government, that such examinations ought to be made general as to the results of all outlays for sanitary works, and should be employed more closely, strictly, officially, and responsibly for the protection of the ratepayers against works which, instead of relieving, aggravate the burthens and the evils which are inherent to insanitary conditions, and throw discredit upon sanitary science. The first questions which ought to be insisted upon, in relatiou to past expenditure on works for sanitary purposes were—Did they or did they not reduce death-rates as promised? and—Were they paying? If not, there had been culpable ignorance, malfeasance, or misfeasance, to which serious responsibility ought to attach. For the future such examinations would serve to show more clearly than was yet generally known what did do, as well as what did not do. On such examinations, as those he had displayed in his paper, it was proved that an expenditure of about £5 per house, or of about £1 per head of the population, for combined works of water supply, and house and main drainage —roughly carried out, as they had mostly been— effected reductions of death-rates to the extent of five per thousand of the population. In other words, every pound per house of expenditure correctly applied had effected and would effect a reduction of one death per thousand of the population. An examination of the results of some millions of expenditure, attended with augmented burthens on the rates, was due to the ratepayers and to future progress. Long after the works on which that expenditure was incurred had been completed, and were in full operation, the death-rates in the metropolis, which an effective expenditure under sound sanitary science would have largely diminished, had remained stationary or had increased. For the two last completed decades, the general death-rates in the metropolis had increased. It was proper to note, too, on the sewage question, as showing how much light was yet needed—that even Sir Henry Cole had much to learn, and had especially to inform himself more correctly as to the character and value of the pretensions of some of his authorities. In his paper on the sewage question he had used these terms:— "An opinion has been expressed by civil engineers of knowledge and experience that sanitary science has been retarded by the antiquated prejudices of the inspectors of the Local Government Board in favour of irrigation. A late president of the Institute of Civil Engineers once said to me—'The simple result of the utilisation of sewage by irrigation is the production of a penny cabbage at the cost of 6d., and a pestilential neighbourhood besides.'" It is such engineering as this that allows a double and three-fold waste of water in dry weather, and, in wet weather, throws the rainfall and the storm water, which is due to the river, into gigantic tunnel sewers —by all of which excessive and wasteful dilution the quantity of manure had been reduced to a pennyworth or even a halfpennyworth in a ton of water, and rendered almost valueless for carriage. Some such augmentation in expense as had been spoken of, with incommensurate amount of production, might be displayed as attendant on the works of insanitary engineers. But the value of their dicta was displayed from more correct and economical sanitary works

inside and outside the towns—inside the towns in self-cleansing house drains and smelless sewers; outside the towns in unprecedented crops, such as of more than a hundred tons of mangolds to the acre, and in surprising cabbages of half a hundredweight each, of superior quality, and several worth sixpence each; and, generally, in repeated instances such as were displayed at Croydon and Bedford, where, whilst the common agricultural production was as one, and market gardening as three and a half, the sewage yield was as five and more, and the qualities superior. As to the economical results, an official inquiry on sewage farming had declared it to be remunerative for the investment of capital under fair conditions of appropriate economy, unextortionate rents, and appropriate skilled labour. It might be averred generally that the efficiency and value of sanitary works such as those in question, and of the qualifications for sanitary engineering, might be tested popularly by the nose, from foul smells in the house, in the streets, and on the field, which denoted waste of manure, as well as by continued excessive death-rates and ill-remunerative works.

Mr Baldwin Latham then stated the substance of his paper, "Works of Sewage and Sewage Disposal—Croydon Sanitary Authority."

Sir Henry Cole asked how long the brick rubbish used for the filter would last?

Mr. Latham said there was no limit practically, because it was self-purifying. It was worked on the intermittent principle. Oxidation took place, and the soluble matters were washed away. A filter, six feet deep and one acre in extent, would purify the sewage of 3,000 people.

Sir Henry Cole said he was not, as some people seemed to suppose, a disbeliever in irrigation. He suspended his judgment upon the value of water-carried raw sewage for irrigation, but in order to show that he was quite unprejudiced, he would tell the story of a sewage farm whose results were about as good as Mr. Latham's. The Duke of Sutherland's seat at Trentham was within two miles of Longton. That town had a very few water-closets, but a great number of houses, of which the middens drained into the sewers, whilst all the storm-water was kept out of the sewers, and, therefore, all the valuable properties of the excreta from the middens were preserved. The Duke had, also, an inexhaustible quantity of thirsty land at Trentham, and the result of taking the sewage of Longton, and putting it on his farms as it was wanted, had the effect of doubling the annual value of the land, whilst the town of Longton gave him £500 a year to do it, and rid the town of its filth. But this financial success was nearly unique.

Mr. Grindle (of Hertford) said, being the engineer to the Buckhurst-hill Sewage Works, he might state that there were four filters, 40 feet square and 6 feet deep, made of crushed burnt ballast. This material, when examined under the microscope, appeared almost like a piece of charcoal, full of pores. These intermittent filtration works were constructed in 1872, and had been in successful operation ever since, and never changed. Each filter was allowed to rest 18 hours out of the 24 for aeration. The effluent had been analysed, and gave very satisfactory results. It was poured into a river called the Roden, which was a very small stream. He should think the effluent was about one-tenth of the stream.

Sir Henry Cole said one of the highest chemical authorities having analysed the water in a similar case, thought it was quite safe to put the effluent, filtered in that way, into a stream of 10 times its volume, but another authority, equally eminent, said the stream should be 50 times the volume.

Lieutenant-Colonel Jones next gave the substance of his paper, "Sewage Disposal at Wrexham."

Mr. Lemon asked Colonel Jones if he could give a description of the machinery he used for drying sludge?

Colonel Jones said he described at the last Conference the machine which he was then using. He was at present using another on the same principle, which consisted simply of an iron cylinder of about 4 feet in diameter, made of light boiler plating, about 29 feet long. The sludge was poured in at one end, and there was a worm inside which kept it stirred about, and an iron pipe with a fan drew the gases from the furnace through it, the sludge being stirred about in the presence of the gas. The only essential principle consisted in the action of the sulphurous acid gas of the fire on the sludge, forming sulphites of ammonia instead of allowing the ammonia to escape into the atmosphere. The same principle was utilised in the other mode, which was simply passing the sludge through the furnace itself, but he thought that drying was facilitated by blowing the hot gas through it instead of allowing it to pass through the heated chamber.

Mr. Colebrook said he was chairman of the Reading Sewage Farm Committee, and he might give the result of their experience last year, particularly in the growth of mangold under irrigation. The highest weight per acre was 110 tons, and the lowest 77 tons, which, he believed, was the heaviest weight ever known to have been grown. There was this peculiarity in the growth of this mangold. It was intended, in the spring of the year, to irrigate the land while the crop was growing, but the spring was wet, and they were not able to hoe the land when they wanted, and when they were able to do so the weeds filled the trenches, and they could not get the sewage on to the land while the crop was growing. He pointed to that for this reason, that he believed it was quite possible to overdose the land with sewage, and the result they obtained was chiefly owing to not having done so. The crop of rye grass was equally good. Last year they cut six excellent crops of not less than 20 tons per acre each crop, whilst the year before they had seven crops. This year, the spring being so backward, they had lost the first crop entirely. They had rigidly excluded storm-water, and he attributed a great deal of their success to the fact.

Mr. Chadwick asked how they got on with cabbages?

Mr. Colebrook said they had only tried cabbages twice, because the farm was as yet imperfect. One crop was very good, but the other was spoiled by being overdosed with sewage, because they had not a sufficient area of land ready to take it, and were obliged to sacrifice the crop for the sake of disposing of the sewage?

Mr. Cresswell asked Colonel Jones if he had had sufficient experience of Mr. Shone's machine to say whether, in such a place as Southport, where it was absolutely necessary to have a series of pumping engines, such a machine might be applied with advantage; and, if so, whether his experience enabled him to tell the Conference whether there would be any economy in it compared with the ordinary steam-engines?

Dr. Seaton asked Colonel Jones whether he apprehended that some extra means would have to be provided for flushing the sewers if storm-water was excluded?

Colonel Jones said his belief was that, if the sewers were constructed for carrying sewage alone they would never require flushing; the ordinary flow of the sewage would be sufficient, being always moving; but if, from any exceptional cause, they require flushing, it could be done very readily, either by letting water into them or from damming it up temporarily in some places and then letting the water go with a rush. He thought it a great mistake to depend on the rainfall for flushing.

It came at exactly the time you did not want it; it never came in dry hot weather, when the sewers were full of sewer gas; and when it did come it left behind it a lot of road detritus which choked up the sewer. In reply to Mr. Cresswell's question, he could not say that he had had sufficient experience to form a very decided opinion as to the system answering on a large scale, but from all he had seen he saw nothing to prevent it, and it was thoroughly worth a trial. He knew that one place had almost completed arrangements for trying it under somewhat similar conditions to those named, so that it would not be long before the question could be answered from actual experience. The first objection which occurred to every oue was, that compressed air was an expensive power; but when it was examined it would be found that compressed air had been always adopted with additional friction, which did not enter into Mr. Shone's application of it. He regarded it here simply as a transmitter of power just as a column of water would do, or a strap from one pulley to another. He then explained, by the aid of a large diagram, the action of Mr. Shone's ejector.

Captain Galton said it acted very much like a ram.

Colonel Jones said there were often diffieulties in dealing with pure water and sewage in the same place, but it would be very simple to have two of those ejectors; one to supply the house with clean water, and the other to eject the sewage, both worked by one little air compressor. The great advantages of this arrangement was that the ejectors might be laid down in different parts of the town, and all worked from one central point, and water power might be applied for compressing the air just as well as a steam-engine.

Mr Henry Masters then explained the principle of sewer ventilation, "The Double Check System of House Drainage."

Dr Alcock asked if he rightly understood the system to be that of carrying drains under every house with a pipe on each side.

Mr. Masters said the principle consisted of carrying the air right through a pipe which was open at both euds, so as to keep the drain constautly free from gas.

Mr. Banner then demonstrated his principle—his system of house sanitation, and exhibited a model of his cowl.

Dr. Yeld asked if it was not found in some experiments made at Kew, that open tubes were equally as effectual as cowls?

Mr. Banner said that was the opinion arrived at under the conditions iu which some were tried. The Banner cowl was not one of them. He then fitted a small cowl to the end of an india-rubber tube 60 feet loug, to show its effect in extinguishing a light at the other end. He said with regard to the experiments at Kew, there were several practical ways in which the question could be properly tested without going to such experiments as were adopted there. At Guy's Hospital, for instance, the discharges from one section of the hospital were delivered into a 15-in. drain, 300 or 400 feet long; a cowl was raised upon that, and the power of it was to draw the air or gas the reverse way from that the sewage was running, and discharge it above the roof, and since that had been done they never had the mallest smell at the inlet. If it were contended that it could be done without, all they had to do was to have the cowl taken off. There were hundreds of places where the same thing could be done.

Mr. Watson Craft suggested that the small model cowl which Mr. Banner had been exhibiting was not quite the same as those practically used, because there was no arrangement to enable it to revolve, and thus it fitted more closely on to the tube.

Mr. Banner explained that this made no appreciable difference.

The Chairman said he thought the Conference could not go into the merits of specific inventions.

Dr. Seaton (Nottingham) next read his paper, "On the Substitution of the Pail System for the Privy Midden System in Nottingham, and its effects in reducing the Mortality and Sickness from Enteric and Contiuued Fevers."

Mr. Birkett asked if Dr. Seaton had made any calculation as to what was the saving to be derived per thousand of population where the sewage was properly utilised?

Dr. Seaton said they did not manufacture it all.

Dr. Tripe said it would be interesting to know what was the reduction in the death-rate, in consequence of the introduction of this system.

Dr. North asked what was the cost per house, this being a point on which many towns wanted accurate information, and it was hardly possible to get to know the precise cost of this plan, because it was generally so mixed up with other expenses. No one doubted it was an enormous advance on the old midden system, and the great question for local authorities to consider was what was the cost.

Dr. Vacher asked if the sewage in pails was at once treated with dry sifted ashes, because there would be a great difference whether the soil was left in pails, as at Rochdale, or treated with some dry material at once. In the case of typhoid or cholera patients, it was very important that something dry should be thrown over the excreta, so as to keep them down in the pail, and prevent them pollutiug the air.

Dr. Yeld asked what increase in the rating had been caused by the introductiou of this system. It was a very importaut paper, but it was too late for a public discussion upon it. Many large towns were experimentiug in the same way, and the tub or pail system would be more readily adopted were it not for fear of the expense, inasmuch as local Boards were very often more apt to consider the question of cost rather than that of the public health.

Dr. Seaton said of course the value of the manure was considerably increased by collecting it in pails. At present the value was 2s. 6d. per ton as against 1s., under the old privy system. He could not furnish the cost per house, but he could give the total cost of the working of the night soil department for the past year. In answer to another question, he said the owner of the houses bore the cost of the alteration.

Mr. Alcock asked if they found the owners objected to make the alteratious, and if so, whether they had had any experience of their power to enforce the new system?

Dr. Seaton said iu some cases they had had a good deal of opposition, but in those cases they had proceeded against the owners for a nuisance, and had found no difficulty in getting the law enforced. He had had no hesitation in declaring that a privy midden in close proximity to houses was a uuisance and injurious to health.

Mr. Alcock asked if he had had any experience with regard to isolatiug cases of infectious disease by the working of the new system?

Dr. Seaton said it was one of the advantages of the pail system that, when infectious diseases prevailed in a house, you could take special means for the disinfection of discharges. They used dry ashes as much as possible. The pails were simply small movable middens, into which the dry ashes aud refuse were also put.

Mr. Alcock asked what was the frequency of removal, say, in an ordinary house, occupied by one person with a family or servants, or a tenemented house?

Dr. Seaton said there were altogether in operation at the present time in the extended borough 10,000 pails, and there were 15,000 removals per week, showing that some were removed once a week and some twice. The cost per pail was three farthings, the men being paid by the number of pails they brought in.

Dr. Syson asked if they abolished ash-pits?

Dr. Seaton said yes; the pails replaced the ash-pits.

Mr. Alcock inquired what the three farthings per pail covered?

Dr. Seaton said simply the labour of removal.

Mr. North said it was stated last year that at Rochdale the nett cost was £10,000 per year, or about £1 per house, which was a very considerable item to have to bring before a Corporation.

Dr. Seaton said the total cost of the night soil department during the past year was about £10,000, which included the removal of ashes.

Dr. Tripe said he presumed about £3,000 of that would be due to the removal of the ashes.

Mr. Longdin, Borough Surveyor of Warrington, said in that town there were about 4,000 houses on the pail system. They collected the excreta and ashes in separate pails, and took them to a depôt about one mile from the centre of the town, the ashes were simply burnt and screened, and the fine ash was mixed with the excreta and sold as manure, but they were not at all satisfied with the process; at the same time they held back, wisely he thought, for the present to see what other people were doing. The cost per head of the total working of the night soil department was, including interest on land and building, &c., at depôt, 8d. per annum.

Mr. S. W. North remarked that some of them were interested in towns where there was no collection whatever at present made by the Corporation, and they would like to know the cost of starting such a system. In the town he represented, to talk of an expenditure of £10,000 a year would frighten people at once. He believed it was said last year that the cost at Rochdale was £1 per house after deducting what they obtained by the sale of the manufactured manure.

Dr. Syson believed that the total cost at Rochdale, under the new system, was less than under the old. Certainly, at Manchester, the cost of the old midden system was very much greater than the cost of employing the pails.

Mr. Hewson said he resided at Rochdale, and he understood that the cost of the pail system was much greater than that of the old ashpit system; he also understood that in Manchester the cost of the night soil department had doubled within the last few years.

Dr. Yeld said there was a great increase in the cost at Birmingham owing to the adoption of this system.

Dr. Wilson said until the introduction of the pail system in Rochdale they could get no one to scavenger the closets at all, unless at a greatly increased cost. The charge when they gave it out by contract was yearly increasing, and there was a corresponding decrease of efficiency in the way it was done. At that time Rochdale was in the unfortunate position of having a death-rate very much in excess of what it ought to be, and if they considered the position of such towns, the question of cost ought not to occupy such a prominent position as it had done. In Nottingham they were under peculiarly favourable conditions, because they could at once get rid of the collected matter. It was made a strong point yesterday that there ought to be no appropriating of water from one district to which it more naturally belonged, and sending it to another, and Rochdale, on the same principle, thought it far better not to send their excreta, or poisoned water, into other districts. That was another and very serious element in the cost of this system. He could confirm what Dr. Seaton had said as to the lessened death-rate from fever, although he had not the statistics for the years since 1874, still the constant tendency of that rate was downwards. When Dr. Lyon Playfair inquired into the health of the town, it was found that Rochdale might be divided into two districts, one in a good sanitary condition, and the other in a bad, and it was then shown that the death-rate of that which was in a good sanitary condition, was 23 per 1,000. Since that time the town had largely increased, with a corresponding increase in the density of the population, but he could state now that the general death-rate for the whole was about the average which was then stated to be that of the district in a good sanitary condition, and to make up that rate, of course there were many parts where it was considerably under 20 per 1,000

Mr. North said no one could doubt that the pail system was preventive of disease, but the question was how much it would cost a Corporation to do that which it ought to do, in a case where hitherto it had done nothing? Judging from the knowledge he obtained at Rochdale, he came to the conclusion that the cost would be about £1 per house. At present, as far as he could ascertain, it cost the occupiers of houses on an average from 3s. to 4s. per house for removal at intervals of three or six months, when it was done by private enterprise, and not by the Corporation. This was about the cost in York.

Dr. Wilson thought that Mr. North had not taken into account the peculiar difficulty of Rochdale; the whole thing was forced upon it because it could not get rid of its manure, as many neighbouring towns could, having a large agricultural district surrounding them; but the total cost was much under £1 per house, probably nearer one-half that amount.

Mr. Schofield, of Rochdale, said that place had been passing through a period of transition from hand labour to machine labour, and although the cost of the machines had been considerable, that could not be taken as a criterion of what the system would do when it was got into fair operation, and it did not follow because the town had been put to a large expense during the past year, that it would be in the same ratio afterwards. When they commenced in 1870, they had only 527 closets under the pail system; it had gone on, until last year there were 950 without pails. Now there were only 1,000 of the population with the old closets, and 2,000 with water-closets, and probably within the next few months it would be entirely done under the new system, and that almost entirely without compulsion.

The Chairman said he hoped now he might be allowed to bring the proceedings to a close. The first question which occurred was how the previous Conference compared with the present, and would the result of the present afford a sufficient inducement to gentlemen to re-assemble next year. In that respect he thought he might congratulate the meeting. They had enlarged the subject matters of inquiry, and if some portion of the vast and complex subject had rather been put in the shade, it was simply from want of time to fully discuss every point. He referred especially to the subject in the paper of Dr. Seaton. This Conference had shown such a special interest in this subject that he regretted it was not taken earlier, but probably the Council of this Society were led to place it rather late in order of subjects because it had been discussed upon many previous occasions, and the Conference had already passed resolutions on the subject to which he would draw attention. In 1876 and 1877 the following resolutions were passed:—

1876.

That the protection of public health from typhoid and other diseases, demand that an amending Act of Parliament be passed, as soon as possible, to secure all house drains connected with public sewers in the metropolis, and towns having an urban

authority, should be placed under the inspection and control of local sanitary authorities, who shall be bound to see to the effective construction and due maintenance of all such house drains, pipes, and connections. Provisions having this object in view already exist in the Act constituting the Commissioners of Sewers in the City of London, in the Metropolis Local Management Act, 1855, and in the Public Health Act, 1875, but practically they seem scarcely sufficient for the purpose.

1877.

1. That the pail system, under proper regulations for early and frequent removal, is greatly superior to all privies, cesspools, ash-pits, and middens, and possesses many manifold advantages in regard to health and cleanliness, whilst its results in economy and utilisation often compare favourably with those of water-carried sewage.

2. That hitherto no mode of utilising the excreta has been brought into operation which repays the cost of collection.

3. That the almost universal practice of mixing ashes with the pail products, though it applies these as a convenient absorbent, and possibly to some extent as a deoderant, is injurious to the value of the excreta as manure.

4. That, for use within the house, no system has been found in practice to take the place of the water-closet.

5. That, although there are appliances and arrangements by means of which the sewer-gases may be effectually prevented from entering houses, they still do so in the great majority of dwellings, both in town and country, including the metropolis.

6. That it is of the highest importance, in a sanitary point of view, that the metropolitan and local authorities should exercise great vigilance with respect to this matter, and that it should be made by law the duty of these bodies to enforce efficient measures for the exclusion of sewer-gases from dwellings, and to watch over their being efficiently carried out under such a system of payment as shall not press too heavily on those at whose charge the work is done.

7. That in every large town plans of its drainage should be deposited with the local authorities, and be accessible to the public.

8. That all middens, privies, and cesspools in towns should be abolished by law, due regard in point of time being had to the condition of each locality.

He took it, therefore, that this Conference, not only this year but in previous years, had always been of opinion that privies and middens ought to be abolished within a reasonable time, and that the pail system was a vast improvement on those old methods of dealing with excreta. They had not exhausted, and probably had not had sufficient experience to exhaust, the question of the comparative cost of the pail system, which was a very interesting subject of inquiry from the point of view of those especially who believed in the system as one calculated to prevent the spread of disease, and who desired to know the cost of its application to the towns in which they were interested. They had had figures from time to time on the subject, and he would venture to suggest that, next year, their friends at Rochdale, who had been improving and completing their machinery, should come prepared with a special statement of the cost as compared with other methods of dealing with sewage, with the object, not merely of showing what they had done, but of informing the representatives of other towns on the subject, and of enabling them to judge how far the pail system could be applied to other communities, and at what comparative cost. He had always felt, and had said on former occasions, that at any rate the pail system was efficacious. You dealt with the evil at its source, and in some respects before its source—at any rate before the source of that great evil of modern times, sewer gas. If you dealt with excreta in the house itself, however troublesome and expensive it might be, compared with some other system, you dealt effectively with it from a sanitary point of view. There was also another advantage. It might be a costly system if you took the cost per head of the population, but, at any rate, you had this advantage, you were not sinking money which might be mistakenly sunk in large works, which might turn out to be constructed on some wrong principle, or which, even if they freed you from the source of evil, might carry it to your neighbours. Therefore, he said, that in the present state of knowledge as to the methods of purifying sewage conveyed by water, unless you had a large and dense population and some easy opportunity of an outfall, it might very well be the least costly method, in the long run, to be contented for the present with the pail system. However, he did not think it was a subject on which the Conference would like to arrive at a resolution at present, but he hoped their friends at Rochdale would bring further details as to cost next year. During these two days there had been a great variety of interesting papers and discussions, and certain resolutions had also been passed. The first day was appropriated to discussion of the great question of National Water Supply, on which a resolution was passed, and it was determined, after considerable discussion, that the meeting would adhere to the policy taken up by the Council and the Conference last year, and throw on the Government of the day the onus and responsibility of dealing with the question by a Royal Commission of Inquiry. He did not know what the probabilities of action were by the Government; if they acceded to the request of the Council, conveyed by the Prince of Wales, then they had reason to believe that the whole subject would be investigated by the most competent scientific knowledge, and certainly no scientific men connected with this subject would be otherwise than satisfied by the subject being dealt with, explored, and explained by such a machinery as that. If the Government did not accede to the request, then he thought that the Society of Arts should take some action, without waiting for next year's Conference, and he hoped they would allow him, as Chairman, in such a case, to press on the Society the necessity of taking some immediate action on the subject. Then came the exceedingly interesting papers of Dr. Thorne and Mr. Ernest Hart, and the contribution to the same subject in the speech of Mr. Baldwin Latham. Dr. Thorne's paper was very interesting to him in more ways than one. It was interesting to all, because of its ability, lucidity, and the remarkable characteristics of the case. It was precisely a case—simply explained as he explained it—calculated to convey to the public mind the ways by which scientific men could trace the evil to its source, and the use to society of the application of such methods of scientific investigation. But it was interesting to him from another point of view. As an ex-president of the Local Government Board, he was delighted that the medical department of that Board had an opportunity before that Conference of presenting itself in an aspect so favourable to all who were interested in sanitation. It was fulfilling precisely the true functions of the medical department of that Board to undertake to conduct such inquiries, as that department was a scientific one, and its duty was to conduct investigations which other persons might not be equally able to conduct, which served to guide Local Government Boards throughout the country, and these results were published in the annual reports of the Local Government Board, and thus were generally accessible. On that matter a resolution was passed, of which the meeting would have no cause to repent. The temptations had been avoided of pronouncing as a mixed body on a purely scientific question; they had eliminated all that was purely scientific out of the proposal with which Dr. Thorne's paper concluded, and passed a resolution which he thought they were justified as practical men on the evidence before them in arriving at. Then he came to the paper of Sir Henry Cole, who first referred to a suggestion of his own in a former year, that in a public department like the Local Government Board, there ought to be an Inquiry Office. They had not constituted one, and Sir Henry Cole thought the Society of Arts should do so. He should be delighted if the Society could see its way to establish an Inquiry Office on this subject, but the difficulty which they could all easily understand was one of ways and means. It meant a room devoted to the purpose and one or two persons, one of whom at least should be highly qualified, and both of whom should be paid for rendering a service which would be necessary to the regular conduct of a department of that description. He was not sure that it would be within the means of the Society to undertake such an experiment, or

whether Sir Henry Cole made the suggestion with any knowledge as to the intentions of the Society. He limited himself to the expression of opinion that it was a fit thing for the Local Government Department to undertake, and that if it were to do so, it would add very much to the smooth working of their own department, and to the progress of sanitation throughout the country. Then Sir Henry Cole passed on to another subject, and referred to the very interesting letter from the Duke of Sutherland to Mr. Sclater-Booth, who proposed federation of local authorities. The existing law provided for that federation as far as it could do so in the original Local Government Act, which gave power for local sanitary districts to combine in aggregate areas for some commou purpose, by provisional orders requiring confirmation by Parliament. The reason why he had inserted that provision, was this. He did not say to himself that it would have a great practical effect, because you did not easily get 12 or 20 local authorities to combine and press a provisional order through Parliament, but it seemed to him to lay down a principle which might have practical results, and would at any rate have some result in further legislation at a future time. What that result ought to be he would not say at preseut. Theu he came to Mr. Cresswell's interesting paper, and the resolution passed thereon. Mr. Cresswell's paper was upou the general subject of the impure conditiou of the River Thames with special reference to that part of it with which he himself was most familiar. In that resolution, again, he thought they had gone as far as it was advisible for such a Conference to go, and that the further responsibility ought to be left with the Government of the day. Now, to go back to two matters on which he had already touched, the first of which was that of National Water Supply, on which he hoped a Commission would be appointed, and the second was the proposal of the Duke of Sutherland for the federation of local authorities for the purpose of dealing with questious of the prevention of river pollution. Both of those subjects were connected with this general consideration—the necessity for making provision, for many purposes, for larger areas of Governmeut than those which already existed. As far as the supply of water was concerned, the tendency of the scientific mind was towards water-shed areas and authorities, aud he found no fault with that as a scientific view. As far as the view raised by the Duke of Sutherland was concerned, he supposed the view was simply this, that you could not conserve the purity of certaiu rivers without, at auy rate, very much enlarging the area within which you carried out measures for their preservation. But he had another poiut of view to which he should like to direct attention, not for the first time. He had often said that after all this question was not a mere question of health but of local government, and he said that in the interests of health as well as in the interests of local government. Iu questions of health you could uot drive the country but you could lead it, aud you could only lead the country through represeutative institutions of some kind. You could educate the representatives whom those institutions brought into public action, and what he desired was this, that in a proposal of this kind, from a scieutific point of view, you should uot forget what he called the local government point of view; and, collating those two ideas, he was coutiuually reminded of the importance, which he, for one, had never forgotten, of passing a measure for the formatiou of County Boards. That scheme for County Boards was one propounded during the time of Mr. Gladstone's Government, some six years ago, and by himself as the member of that Government charged with the subject. It had been dealt with by his successor in the Local Government Board, and by various persons in the House of Commons, but it had never gone further thau the second reading, if so far. There was a great difficulty in the way, so far as the House of Commons was concerned, that there was a great objection, on the part of many people, to the coustruction of Boards, which they thought might not end in economy, but in additioual expenditure. He was not prepared to say that they would uot end in additional expenditure, but he had often used this language, that although saving was profitable, profitable expenditure was more profitable that mere saving. If you had Boards rightly constructed for large areas endowed with considerable powers, so that you might hope to attract the best men of the locality to serve on them, although you might get an increased expenditure, you would get a greater return in the shape of greater convenience, comfort, and happiness, aud health of the population concerned. With regard to the question of water supply, he would not lay down auy hard and fast rule or line. He did not say that the County Board of the future was to be the authority for the conservancy of all the rivers within the county; it might be advisable to enlarge the area of the conservaucy and the preveutiou of pollution. All that he would say would be this, bear in mind that you have to construct these County Boards, and endeavour to harmonise their future with this idea of the future conservancy of rivers, and this might be done with the most perfect ease. If it were necessary to combine one or more counties for the purpose of forming a water-shed area, you had only to make it a combined authority, instead of setting up one *de novo*, and he did not believe that the difficulties would be at all serious, and, at any rate, adhering to this view, you ought not to cross the county lines iu the construction of auy one of these water-shed authorities. They had had experience of crossing boundary lines, and the multiplex combination of sanitary areas, and had endeavoured, by legislation, to reduce the number of those areas and simplify them; and he trusted in future, as they had of late, they would endeavour to adhere to this very simple rule, which he did not think would be found impossible of application. They should start with the administrative unit, the simplest area you had in the country, the local government area, the urban or rural sanitary district. That was an area for certain purposes of local government. He desired that it should not be too small, but when you wanted a larger area for some common purpose, the simple rule in his own miud was to have an aggregate of those smaller areas, never to divide them. You might meet with some difficulties, but depend upou it, for the sake of simplicity, iu the long run, it would be better to meet them at first. If you once laid down the principle, the thing became very simple. You had these units of administrative area, and for purposes in which you required large areas you formed an aggregate of those units, it might be one county or two counties. The meetiug to-day had been rather loug, but he hoped uot uninteresting or uuimportaut. He hoped the meeting would agree with him that this Conference might compare favourably with those of past years, and that gentlemeu would be williug to come again next year, aud again take up this useful aud necessary public work.

Dr. Yeld, in proposing a vote of thanks to the Chairman, said he quite agreed with him that the Conference had beeu a great success; mauy of the papers were very valuable, and he was sure that all would agree with him that the very able manner in which the Chairman had summarised the proceedings was, in itself, a treat to everyone who had heard it.

Mr. Birkett seconded the resolutiou, which was carried unanimously, and the proceediugs termiuated.

The Papers will be printed in subsequent numbers of the *Journal*.

MISCELLANEOUS.

THE COACH-MAKERS' EXHIBITION.

The Coach-makers' and Coach-Harness-makers' Company have been engaged for several years in the attempt to enlarge the knowledge of their trade among coachmakers' assistants and apprentices. In 1865, the Operative Coach-makers' Industrial Exhibition was opened, in the Company's hall, by the Marquis of Lansdowne. In 1866, the Company voted medals, to be awarded by the examiners of the Society of Arts, and in 1867, 1869, and 1870 they made a grant to the Society in aid of examinations. In 1871, and subsequent years, medals were voted for award by the Science and Art Department. This year it was decided that an exhibition, on a larger scale than those hitherto projected, should be held. The exhibition, which took place in the Mansion-house, was opened on the 2nd inst., and consisted of the following classes:—1. Competitive drawings by coachmakers' apprentices of carriages and parts of carriages, studies in freehand drawing, and technical drawings to scale. 2. Representations of state carriages of the past and present, and of all countries. 3. Private and ordinary carriages, from an early date to the present time. 4. Photographs of all descriptions of conveyances. 5. The literature of carriages, comprising a valuable collection of works, historical and pictorial, bearing upon every branch of the subject. Mr. George A. Thrupp (who delivered the Cantor Lectures on "The History of the Art of Coachbuilding" in 1876) contributed a series of drawings of old Egyptian chariots, and early Roman, Saxon, and English cars, litters, and carriages; and most of the large coachbuilding firms sent objects of interest, to illustrate the history of the art. Mr. Thrupp's collection of works on the history of coaches is very complete, and contains Garsault's treatise on Carriages (Paris, 1756), which is the earliest work on the subject. The exhibition was closed on the 6th inst., when the Lord Mayor distributed the medals and certificates to the successful exhibitors.

GENERAL NOTES.

National Training School for Music.—It is announced that the first public concert will be given by the students of this school at St. James's-hall on Monday evening next, June 23rd, under the patronage of her Majesty, and that the Prince and Princess of Wales, the Duke and Duchess of Edinburgh, and other members of the Royal Family, have signified their intention of being present.

Transmission of Motive Power.—M. Tresca laid before the French Academy of Sciences, at a recent meeting, some information on this subject. On the Lyons Railway a force of from two to three-horse power had been transmitted to a considerable distance, to work a crane, by means of an electric wire. He stated that only last week he had witnessed other experiments of a similar nature at Sermaize (Marne), but in this case the trials were of a more precise nature, and their object was to plough land by electricity. The apparatus consisted of a steam-engine setting in motion a Gramme machine, producing a voltaic current which, at a distance of 400 metres, acted on two Gramme machines at opposite sides of the field, and from these the windlasses of the steam plough were driven. M. Tresca has not yet been able to determine the cost of this process of ploughing as compared with other systems, but he is about to carry out a series of experiments at the Conservatoire des Arts et Métiers, to determine the question. He is of opinion that the expense will not exceed that of other methods now in use.

NOTICES.

SANITARY CONFERENCE.

The Pamphlet containing a full report of the papers and proceedings of the late Conference on National Water Supply, Disposal of Sewage, and Health, will be published shortly, price 2s. 6d.

Applications for copies of the Report should be addressed to the Secretary.

MEETINGS FOR THE ENSUING WEEK.

Mon., June 23rd...Aeronautical (at the House of the Society of Arts), 8 p.m. Reading and Discussion of papers. Experiments on flight continued.
Royal Geographical, University of London, Burlington-gardens, W., 8½ p.m. Reports received from Mr. Keith Johnston, commanding the East African Expedition:—1. "Excursion to the Usambara Hills." 2. "Information obtained regarding Routes between Dar-es-Salaam and Lake Nyassa."
British Architects, 9, Conduit-street, W., 8 p.m. Presentation of the Royal Gold Medal to the Marquis de Vogüe, author of works relating to Civil and Religious Architecture in Egypt and Syria. A short address by the President.

Tuesday, June 24th...Statistical, Somerset-house-terrace, Strand, W.C., 3 p.m. Annual Meeting.
Anthropological Institution, 4, St. Martin's-place, W.C., 8 p.m. 1. Prof. W. H. Flower, "The Osteology of the Natives of the Andaman Islands." 2. Mr. Worthington G. Smith, "Palæolithic Implements from the Valley of the Brent." 3. Mr. J. R. Mortimer, "'Kemp How' Cowlam." 4. Mr. W. J. Knowles, "Portstewart and other Flint Factories of the North of Ireland." 5. Mr. W. J. Sollas, "Some Eskimos Bone Implements from the East Coast of Greenland."
Royal Horticultural, South Kensington, S.W., 1 p.m.

Wed., June 25th...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 4 p.m. Annual General Meeting. Council's Annual Report, Election of Officers, &c. 8.30 p.m., Annual Conversazione, at the South Kensington Museum.
Geological, Burlington-house, W., 8 p.m. 1. Mr. J. D. Kendall, "The Formation of Rock-basins." 2. Mr. W. Percy Sladen, "*Lepidodiscus Lebouri*, a New Species of *Agelacrinites*, from the Carboniferous Series of Northumberland." 3. Prof. H. G. Seeley, "Evidence that certain Species of *Ichthyosaurus* were Viviparous." 4. Prof. H. G. Seeley, "*Rhamphocephalus Prestwichi*, Seeley, an Ornithosaurian from the Stonesfield Slate of Kineton." 5. Mr. E. Wilson, "The Physical Geography of the North-East of England in Permian and Triassic Times." 6. Mr. S. Allport, "The Diorites of the Warwickshire Coal-field." 7. Mr. George Attwood, "A Contribution to South American Geology." 8. Mr. J. Buckman, "The so-called Midford Sands." 9. Mr. C. B. Brown, "The Ancient River Deposit of the Amazon." 10. Mr. Clement Reid, "The Glacial Deposits of Cromer." 11. "Notes on a Disturbance of the Chalk at Trowse, near Norwich." 12. Mr. T. M. Hall, "The Submerged Forest of Barnstaple Bay." Mr. T. Mellard Reade, "A Section of Boulder Clay and Gravels at Ballygally Head, and an Inquiry as to the Proper Classification of the Irish Drift." 14. By Senor Salvador Calderon, communicated by the President, "The Augitic Rocks of the Canary Islands." 15. Mr J. E. Marr, "The Cambrian (Sedgw.) and Silurian Beds of the Dee Valley, as compared with those of the Lake District." 16. Rev. A. H. W. Ingram, "Some Superficial Deposits in the Neighbourhood of Evesham."
Royal Society of Literature, 4, St. Martin's-place, W.C., 8 p.m. Mr. C. H. E. Carmichael, "The Paris Literary Congress of 1878, and the International Association."

Thurs., June 26th...Women's Protective and Provident League (at the House of the Society of Arts), 8.30. Annual Meeting.
Antiquaries, Burlington-house, W., 8½ p.m.
Royal Society Club, Willis's-rooms, St. James's, S.W., 6.30 p.m. Annual Meeting.

Fri., June 27th...Quekett Microscopical Club, University College, W.C., 8 p.m.

Sat., June 28th...Physical, Royal Indian Engineering College, Cooper's-hill, 3 p.m. Papers will be read by Prof. McLeod, Prof. Unwin, Lieut. G. S. Clarke, R.E., and Mr. J. W. Clarke.
Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

JOURNAL OF THE SOCIETY OF ARTS.

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FRIDAY, JUNE 27, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

FOSTER TESTIMONIAL FUND.

The committee of this Fund have passed the following resolution:—

The Committee having ascertained that in Mr. Foster's will he has expressed a wish that anything he might leave at his death should be administered by his widow for the interests of his children, resolves that the Testimonial Fund for the late Secretary of the Society of Arts should be paid to Mrs. Le Neve Foster in accordance with that desire.

(Signed),
Hatherley, Chairman of the Committee.

As soon as the accounts of the fund have been formally audited, a statement will be published, and the amount handed over to Mrs. Foster. The amount available is £1,840, and there yet remain a few subscriptions to be received.

ANNUAL GENERAL MEETING.

The Annual General Meeting, for receiving the report from the Council, and the Treasurers' Statement of Receipts, Payment, and Expenditure during the past year, and also for the Election of Officers, was held, in accordance with the Byelaws, on Wednesday last, the 25th June, at four p.m., Lord Alfred S. Churchill, Chairman of the Council, in the chair.

The Secretary read the notice convening the meeting, and the minutes of the previous annual meeting, and also the minutes of the Special General Meeting for the alteration of the Bye-laws held on the 16th June.

The following new members were then balloted for, and duly elected members of this Society:—

Leopold, H.R.H. Prince, K.G., K.T.
Barker, Edward Dunning, 45, Bedford-row, W.C.
Billington, Rev. James, 31, Wellington-road, Bow-road, E., and 20, Warwick-lane, E.C.
Blakesley, Thomas Holmes, M.A., 26, West Cromwell-road, S.W.
Bradford, Thomas, Crescent Iron Works, Salford, Manchester, and Springfield, Eccles, Manchester.
Browning, Benjamin, 70, Union-road, Rotherhithe, S.E.
Buxton, Sir Thomas Fowell, Bart., Warlies, Waltham Abbey.
Coate, James, F.R.G.S., 41, Lisle-street, Leicester-square, W.C., and Chard, Somersetshire.
Cowper, Hon. Henry Frederick, M.P., 4, St. James's-square, S.W.
Craig, Wm. Young, 2, Cambridge-gate, Regent's-park, N.W.
Croft, Henry, care of J. S. Mitchell, Kent Brewery, Sydney, New South Wales.
Davis, Frederick William, 6, Duke-street, Adelphi, W.C.
Fairclough, Morrison, Pittarrow, Croydon.
Fife, Lieut.-Gen. James George, 7, Collingham-road, South Kensington, S.W.
Goldsmid, Sir Julian, Bart., M.P., 105, Piccadilly, W.
Goodall, Abraham, F.R.C.S., F.R.G.S., 4, Elvaston-place, Queen's-gate, S.W.
Gray, R. Kay, Telegraph Works, Silvertown, Essex.
Hallowes, William Alexander Tooke, 32, Tavistock-square, W.C.
Holland, Walter, Mayor of Worcester.
Hollway, John, 2, Highbury-grange, N.
Hyde, Samuel, M.R.C.S., Buxton-house, Buxton.
Kerr, Richard, 19, Copthall-place, Folkestone.
Law, Henry, 5, Queen Anne's-gate, Westminster, S.W.
Layton, Thomas, Kew-bridge, Kew.
Marshall, Edward James, 11, Vere-street, Oxford-street, W.
Merewether, Sir William L., K.C.S.I., 31, Linden-gardens, W.
Molineux, Gisborne, 5, Holland-villas-road, Kensington, W.
Owen, Henry, 16, Sussex-place, Brompton, S.W., and 114, Marlborough-road, S.W.
Phillips, John, Aller Pottery, near Newton Abbott, Devon.
Phillips, John W., 32, Lewisham High-road, S.E.
Phillips, William, 25, Coal-exchange, E.C.
Salmon, R. H., Caterham Court, Surrey.
Sandys, Major Myles, Graythwaite-hall, Lancashire, and 87, Jermyn-street, S.W.
Skrine, Henry Duncan, Warleigh Manor, Bath.
Stoffel, Louis Marie, 39, Adelaide-road, Regent's-park, N.W.
Stoker, George Naylor, The Laboratory, Somerset-house, W.C.
Strugnell, John, 5, Little George-street, Westminster, S.W.
Walter, John, M.P., 40, Upper Grosvenor-street, W.
Ward, Frederick, 106, Warwick-road, Kensington, W., and 23, Regent-street, W.

And as an Honorary Corresponding Member:—

Alvear y Lara, His Excellency Dou Francisco, G.C.I.C., Havana, Cuba.

The Chairman nominated Mr. H. M. Holmes and Mr. Christopher Cooke scrutineers, and declared the ballot open.

The Secretary then read the following

REPORT.

It is one of the fundamental rules of our Society that at the end of each Session the Council should bring before the members a report of their proceedings during the year, and render an account to them of the way in which they have carried out the trust reposed in them a year before.

In accordance with this useful and salutary provision, the Council have now to lay before the general body of members the report of the 125th

Session of the Society of Arts. During a time of such wide-spread commercial depression there would have been no cause for surprise if the Society had felt the changes which have been passing over the industries of this country, since it is upon the welfare of those industries that the welfare of a Society such as this must depend. It would indeed be impossible for us, intimately associated as we are with the commercial prosperity of the country, not to be more or less affected by any causes which may tend to diminish that prosperity; and it is, therefore, with a feeling of sincere satisfaction that the Council are able to report that the revenues of the Society have been but very slightly, if at all, diminished by the existing depression of trade, great and wide-spread as that depression has been. As regards the numbers also of our members, we are certainly holding our own. We have elected 282 members, as compared with 256 elected in the previous session. We have lost, by death and resignation, 307, as against 350 in the year 1877-8. Thus in both respects there is a decided improvement, though we cannot now show that rapid increase which we should, in better times, expect.

And while there were causes external to the Society which might have been expected to produce ill effects upon it, there were also losses within it which might have tended in the same direction. The sudden death of one who had faithfully served the Society through twenty-five years—a fifth of the whole term of its existence, and certainly not the least important portion of that term—might have been felt as a rude shock to its fortunes. It is with feelings of the most sincere regret that the Council have to refer to the deep loss the Society has sustained by the death of its valued and respected Secretary, Mr. Le Neve Foster. This event is too fresh in the recollection of members to make it necessary to dwell upon it now. Suffice it here to say that the truest testimony to the soundness of Mr. Foster's work is to be found in the fact that, when he left it, he left it in such a state that it could be taken up and carried on without break of continuity by those upon whom the duty fell.

It appeared to the Council that the right and fitting thing to do was to try and mark their sense of the value of Mr. Foster's services, by making some provision for those he had left behind. The funds of the Society are not large enough to admit of any great amount being devoted to such a purpose, nor is the constitution of the Society such as to justify any considerable application of its revenue in this way. However, the Council felt that they would be acting in consonance with the wishes of the members, in recommending, for the adoption of the general body, a resolution allotting to Mr. Foster's widow a pension during her life of £100 per annum. This much they felt they might fairly and justly do, and they are glad to think that this grant on the part of the corporate body will, if it be passed, be supplemented by the individual liberality of the members, who have subscribed an amount which, after deducting necessary expenses, will be over £1,800, to the Foster Testimonial Fund. This sum, intended, in the first instance, as a testimonial to Mr. Foster himself, will now be handed over for the benefit of the members of his family.

I.—Ordinary Meetings.

In considering the work of the past year, we may commence with what is, after all, the principal portion of the Society's labours, the regular evening meetings. Looking at the character of all the papers which have been brought before the Society during the year, the Council feel that they will compare favourably with those of any previous session. In all, 39 papers have been read at the Ordinary and Sectional meetings, papers dealing, as is usual, with subjects the most varied. It is, indeed, the special province of this Society to take within its scope interests of the most wide and different nature, and it has seemed to the present Council, as to their predecessors, that the interests of the Society are best promoted by the widest possible interpretation of the constitution allotted to it in its charter.

The business of the session was successfully commenced with a paper by Captain Burton, the well-known traveller, who was, fortunately, then paying a short visit to England, and availed himself of the opportunity to bring before the Society the results of his recent explorations into the little-known country of Midian. As might have been expected, the fame of the author, and the nature of the subject, attracted a large audience, who gave every indication of the pleasure with which they listened to a most interesting communication. This was followed by a paper by Mr. J. N. Shoolbred on "Electric Lighting." It was just the time when public attention was so much directed to the subject, and the result was that the Society's rooms were thronged by a crowd of the members and their friends, a crowd much too large for the accommodation available in the meeting-room.

The difficulties which were felt in accommodating the members on that evening have caused fresh arrangements to be made by the Council for any future evenings likely to be equally attractive. For long the Council hesitated to take any steps which might even appear to curtail the privileges of members, but after careful consideration they decided that it would be most acceptable to provide that, as far as possible, seats should be secured to the members, and that the privilege of introducing friends should sometimes be waived. It is proposed in the future on such occasions to suspend the usual rules of admission, and only to admit members who have previously provided themselves with a special ticket. This plan was tried a few weeks ago, and the Council are glad to say that it was attended with complete success, no complaints whatever having been made on the latter occasion.

The third paper of the session was upon "Railways to Turkey and India," by Mr. Hyde Clarke, a member of the Council of the Society. Mr. Hyde Clarke's paper was specially valuable as calling fresh public attention to the subject, and it gave rise to a long and important discussion. The last paper read before the Christmas vacation was by Dr. J. H. Gladstone, F.R.S, a well-known member of the London School Board, the subject being "Science Teaching in Elementary Schools."

It would take too long to discuss the respective merits of all the papers which have been

read since Christmas; they were all of considerable value, but amongst them are some deserving special mention. Mr. Haviland's paper, on "The Distribution of Disease Popularly Considered," was noticeable, as giving its author an opportunity of bringing before the Society a question on which he is our principal authority. The admirable series of maps projected by Mr. Haviland, and prepared under his directions to show the topography of disease, are unique, and have rendered very great service to medical science. In Mr. Hollway's paper on "A New Process in Metallurgy," were embodied the results of some of the most important experiments which have recently been made in that science. Mr. Hollway proposes to reduce metallic sulphides by using the ore itself as the chief fuel for the reduction. This is done by forcing a current of air through the molten sulphides. At first, the combustion is started by using coke, but afterwards it is found that sufficient heat is generated by the oxidation of the sulphides, without any further addition of carbon. The process has not yet passed beyond the experimental stage, but should it prove a commercial success, it will effect a most important economy in one of the largest industries in this kingdom. So great was the interest aroused by Mr. Hollway's paper, that it became necessary to devote a second evening to its discussion; on both occasions the room was crowded, and the discussion was of an important and influential character, the opinions expressed being almost uniformly favourable. Of all the papers read before the Society during the year, Mr. Hollway's is the one the Council consider the most remarkable and the most important. Should the process at all carry out the expectations of its inventor—and he is supported by some of our leading chemists—it will add one more to the many great inventions which it has been the constant aim of this Society to introduce to the world. Should it prove less commercially successful, this Society will have done its duty in helping to publish what is at least a most promising scientific experiment. Dr. George Birdwood, C.S.I., a member of the Society's Council read a most interesting paper on "Indian Pottery at the Paris Exhibition." Mr. Edward Rigg contributed a useful paper on "The Compensation of Clocks, Watches, and Chronometers," which described most of the methods in use, and was especially valuable from the number of original authorities collated and referred to. Professor Barff made a second communication on his method of treating iron for the prevention of corrosion, which he first introduced to the world through the medium of this Society, in February, 1877. He has since been further developing the process, and expects soon to be able to apply it on a commercial scale. The paper by Mr. B. Francis Cobb, one of the Society's Treasurers, on "Some Causes of the Recent Depression in Trade," attracted much attention in commercial circles, and has since been much discussed in the newspapers specially devoted to such topics. Another valuable paper was that by Mr. Willis-Bund, on "English Fresh-water Fisheries;" this attracted a great deal of attention amongst the classes specially interested, and was well discussed. Mr. W. Lloyd Wise read a thoughtful and carefully written paper on "The Government Patent Bill." As is usual when patent questions come before the Society, a great deal of discussion arose upon this paper, extending over two nights, besides the one on which the paper was read. The Session was brought to a successful close by a paper by Mr. Conrad W. Cooke, on "Edison's New Telephone," when the new arrangements for the admission of members on popular evenings were tried for the first time. As was the case when Professor Bell read his paper here, two years ago, on his now well-known telephone, the instrument was exhibited in action, and worked to the full satisfaction of a large and attentive audience. Mr. Cooke's paper was a singularly clear *résumé* of the history of the telephone, from its inception in the apparatus of Reis, Varley, and La Cour, down to its latest development in the loud-sounding instrument of Mr. Edison. The current volume of the *Journal* will contain few papers more interesting or more useful for future reference than that of Mr. Cooke.

II.—Indian Section.

In the Indian Section, the usual six papers were read, the first being by Mr. C. E. D. Black, on "Afghanistan." Dr. George Birdwood, who has been, for a considerable time past, at work upon the old records of the East India Company, brought a large portion of his results before the notice of the Society, in a paper on "The Quest and Early European Settlement of India." Dr. Birdwood had to examine, in the course of his official duty, a number of most interesting documents, which throw great light on the history of our early communications with India. He has since been permitted to publish in a Parliamentary paper the information he thus collected, but the members of the Society had the advantage of getting the principal fruits of his researches before the issue of the Blue-book. Mr. J. R. Jackson, of the Kew Museum, read a useful and practical paper on "The Plants of India adapted for Commercial Purposes." This paper has subsequently excited considerable interest, from its mention of the apparently very valuable medical virtues of the *Gynocardia odorata*, from which an oil is extracted of remarkable efficacy in rheumatic and skin complaints. Another plant to which he drew attention was the *Bassia latifolia*, or Matura tree, the fruit of which has remarkable fattening qualities, and is capable of yielding a large amount of spirit in distillation. Two engineering subjects were brought before the Section, "The Ramiscram Ship Canal," by Mr. McBean, and "The Harbour of Kurrachee," by Mr. Price. Mr. McBean took up an old subject from a somewhat novel point of view, and several eminent authorities seemed to think highly of his plan. Mr. Price gave a very clear account of the works completed or now being carried out at Kurrachee. The disadvantage of the absence of the writer in India was fortunately compensated for by the presence of Mr. Parkes, C.E., who had a large share in the original plan and execution of the works, and of Sir William Merewether, lately Commissioner of Scinde, and familiar with all that has been going on in the way of improvement at Kurrachee for many years past. Mr. Wardle's paper on "The Wild Silks of India" attracted much attention, and was of exceptional

value, both on account of the practical suggestions for the development of an important industry in the paper itself, and for the singularly beautiful specimens with which it was illustrated. Many of the examples shown were, in the opinion of experienced judges, of a character hitherto unapproached in colour, design, and material, so far as this special class of fabrics is concerned. For some of the specimens shown Mr. Wardle had already obtained a gold medal at the recent Paris Exhibition. It is to be hoped that the attention thus called to an important raw product of India may have important effects on our home manufactures.

III.—African Section.

In the African Section most of the communications bore upon the now prominent question of the opening up of equatorial Africa, and it was, indeed, for the consideration of this great subject that the African Section was principally founded. Papers were read by Mr. J. B. Cotterill, on "The Exploration and Character of the District to the North of Lake Nyassa;" by Mr. J. Bradshaw, of Manchester, on "The Paramount Necessity of African Trade for the Future Prosperity of the Leading Industries of England;" by Mr. J. B. Fell, on "The Importance of Light Railways for Opening up a Trade with Africa;" by Mr. J. C. Morrell, on "The Probable Effect of Railway Communication in Africa;" and by Mr. Edward Hutchinson, on "The Past Aspects and Future Prospects of the Contact of Civilisation and Barbarism in Africa." Mr. B. Francis Cobb also contributed a useful paper on "The Commercial Condition of Egypt," and Mr. Sivewright gave a most interesting account of "The South African Telegraphs," a subject just at this time of more than usual interest on account of the arrangements in progress for completing telegraphic communication with the Cape. Some modifications which it is proposed to make in the arrangements for this Section will be referred to in another portion of the report.

IV.—Chemical Section.

The Chemical Section also has not been inferior to any of the others in the quality of the papers read. And here the Council must pause for a moment to express their regret at another loss which death has caused in the list of Executive Officers of the Society. Mr. Thomas Wills was associated with the Chemical Section at its commencement, and the success attending it has been owing entirely to his energetic efforts on its behalf. Mr. Wills was cut off at the early age of 28 by a sudden attack of typhoid fever, and the Council feel that by that early death they lose the services of one who was rapidly making for himself a reputation and a name. Fortunately, his work in the Chemical Section was almost completed before he died, and therefore his loss was felt, so far as the actual proceedings of the Section are concerned, almost less in the present year than it will be in the future.

The most important papers brought before this Section were certainly the two by Mr. W. H. Perkin, in which he gave "The History of Coal Tar Colours." For such a task nobody could be better qualified than Mr. Perkin, to whose original discovery was due the foundation of the entire industry. Mr. Perkin not only devoted much time and care to the preparation of his papers, but he also went to great expense in the way in which he presented them to the Society; they were very elaborately illustrated, not only by specimens and examples of fabrics dyed with the colours, but by views and diagrams, which were afterwards reproduced, through Mr. Perkin's liberality, in the pages of the Society's *Journal*. An interesting process, invented by Monsieur Dodé, for coating metals with platinum, was brought before the Section, in a paper communicated by Mr. Stoffel. Dr. W. Wallace read an elaborate paper on "Gas Illumination," which was of special interest, inasmuch as the experiments in London in street lighting, by the use of improved gas-burners, were just at the time being commenced. The paper was fully discussed by the chief authorities on the subject. Mr. Thompson, whose paper the year before last, on "The Sizing of Cotton Goods," will be in the memory of members, contributed a paper on "Methods of Securing Salubrious Air in Large Towns;" and Mr. A. G. Phillips read one upon "Noxious Vapours" with special reference to the report of the late Commission.

V.—Cantor Lectures.

The Cantor Lectures which were delivered during the Session also proved as successful as the Council hoped they would be when they made arrangements for them. The first of these was by Mr. W. Mattieu Williams on "Mathematical Instruments;" the second, by Prof. W. H. Corfield, M.A., on "Household Sanitary Arrangements;" the third, by Mr. W. H. Preece, on "Recent Advances in Telegraphy." All three courses were well attended, especially the two last. Mr. Preece's lectures were practically illustrated by a telegraphic line connecting the Society's Room and the General Post-office, from which messages were sent to illustrate the various systems of telegraphy in use, the ordinary simple system, the duplex, and the quadruplex. The members thus had the opportunity of actually seeing at work the various methods now employed for telegraphic communication. Another interesting feature of these lectures was the exhibition of the beautiful writing telegraph lately invented by by Mr. E. A. Cowper. Mr. Preece was also able, from his position in the Post-office, to show a very complete collection of telegraphic apparatus, recent and old. Prof. Corfield's lectures were well illustrated by specimens from the Parkes Museum of Hygiene, and the attendance at them showed how much interest the members take in the Society's recent action in sanitary matters.

VI.—Additional Lectures.

It will be remembered that, last year, Dr. Richardson gave a very important series of lectures on "Putrefactive Changes, with Special Reference to the Preservation of Animal Substances as Food." During the present Session Dr. Richardson completed the subject by giving two additional lectures. Special interest was attached to these from his being able to bring before the members present specimens which had been preserved by his process, sent over to America, and brought back to England, in the interval between the delivery of his Cantor lectures and of this additional course. The ques-

tion of the supply of food to our growing populations has always been one to which the Society has devoted its attention, nor does this duty appear less incumbent upon it than it was a century ago, when it first attempted to deal with the matter. It is due to Dr. Richardson to remind members that, as a member of the Council, he could not receive any fee for these lectures, which were, therefore, delivered gratuitously.

VII.—Sanitary Conferences.

We have thus passed in review the work done by the Society at its various evening meetings. We may now turn to those special subjects which are taken up by the Council as opportunity arises. The most important of these may perhaps be considered to be the sanitary work to which the Society has paid such special attention during the past few years. It was in 1876, that the idea was first conceived of holding a Conference on the Health and Sewage of Towns. The members are aware that the success attending this first Conference was such as to induce its regular repetition every year since. Last year, upon the suggestion of H.R.H. the Prince of Wales, the President of the Society, a second similar Conference was held on the subject of National Water Supply. During the present year these two kindred subjects were taken together, and treated at a single meeting, which it is satisfactory to be able to state was well attended by persons who came up for the purpose from all parts of the kingdom. The Council have every reason to congratulate the members upon the successful carrying out of this department of the Society's work. Its action has been well received by the public, and has been widely commented upon by the press. Hardly in any instance have these comments been unfavourable. At the meeting held on the 16th and 17th of May last, the Right Hon. James Stansfeld, M.P., presided, as in former years, and the Council feel that to his able assistance so willingly rendered year by year is due no small portion of the success which has attended all these gatherings. Previous to the Conference, the Council had offered prizes for the best suggestions as to methods of dividing England and Wales into districts for the supply of pure water. In answer to the offer a number of suggestions were sent in. Of these the Committee selected two, one by Mr. Frederick Toplis and one by Mr. Joseph Lucas, for the award of silver medals. These two, with five others which the Committee considered to possess sufficient merit or interest, were printed with the papers which were circulated for discussion at the Conference.

In all, 29 papers on various subjects relating to Water Supply and Sewage were brought before the Conference. The subject of Water Supply seemed to attract the greater general interest, and the number of papers contributed on this subject was much larger than that of those relating to sewage or other sanitary questions. Within this latter class, however, there were two which proved of very high interest, and which gave rise to considerable discussion; one by Mr. C. N. Cresswell, upon "The Thames and its Tributaries," the other by Dr. Thorne Thorne on "The Recent Outbreak of Enteric Fever at Caterham." So much interest was manifested in these two papers that the discussion upon them occupied nearly the whole of the second of the two days over which the Conference extended. At the close of the Conference three resolutions were passed; these have already been published in the *Journal*, and the Council have under consideration the best method of carrying into effect the suggestions contained in them.

In leaving this subject, the Council feel it but right to express to the members the sense of the help they have received in these matters from the President, whose ready co-operation and personal interest in the great question of National Health, has been of the greatest value. They feel sure that the part his Royal Highness has taken in the question has been fully appreciated, not only by the members of the Society, but by the nation at large.

VIII.—Sanitary Section.

The success attending the Sanitary Conferences of the Society has led the Council to believe that good might result from the establishment of a permanent department, to carry on similar work more continuously than can be done at meetings held at intervals of a year. They have, therefore, appointed a Sanitary Section, the Committee of which has held several meetings. It has been favoured with the attendance of some eminent authorities on sanitary questions, and the Committee hope soon to be able to publish much useful information which has been placed at their disposal by those gentlemen. The Committee have also had before them a suggestion by Mr. C. N. Cresswell on the subject of a proposed organisation for registering London houses according to their sanitary condition. They have published some correspondence on the subject between Mr. Cresswell and the Right Hon. James Stansfeld, in the hope of eliciting public opinion thereon, and they hope that, later on—perhaps during the coming autumn—they may be able to summon a small Conference of engineers, architects, and other qualified persons, to discuss this very suggestive idea.

IX.—Examinations.

During the past year, some considerable changes have been made in the Society's Annual Examinations. The City and Guilds of London Institute for the promotion of technical education, found themselves in a position, prior to the holding of the Society's Technological Examinations for the present year, to offer to take charge of those examinations, and the Council, acting upon a resolution passed some time ago, have had great pleasure in handing them over to the Institute. The Council hope that, in a very few years, these examinations will, under the direction of the Institute, and supported by the funds at its command, assume a more prominent position than they have hitherto held. In this, as in so many other important movements, the Council feel that the true work of the Society is in inception and initiation. The Society can start new enterprises; it cannot, in general, with its limited funds, carry them out fully. Large expenditure upon a single object would cripple the powers of the Society for other work, and it is, therefore, with a perfect feeling that their share of the work has been accomplished, that the Council have handed over

the Technological Examinations to a body so fully competent to carry them on as they believe the City Institute to be. The other examinations have been conducted in a satisfactory manner, the number of candidates, and the numbers of papers worked, both showing an increase on last year. The full report on the examinations will shortly appear in the *Journal*, and the results will be issued in a day or two. A novel feature has been introduced this year for the first time, in the form of Practical Examinations in Music. For the past two years, the Society has announced its readiness to hold such examinations at any given centre, provided a sufficient number of candidates was forthcoming; but, up to the present time, it has not been found possible to collect, at any locality, a number sufficient to justify such an experiment. This year, however, we were more successful, for examinations of 64 candidates were held at Glasgow, and of 29 at Birmingham. Finding, also, that there were a large number of candidates in London to whom such an examination would be valuable, the Council determined to try the rather novel experiment of forming a centre for themselves, and announced that an examination would be held in the Society's own rooms. The result of the experiment proved the justness of their anticipations, for no less than 117 candidates presented themselves. The examination was held on June the 16th and the two following days. The Examiner reports that most of the candidates who presented themselves were of a high class, and very few failed to obtain the proportion of marks (50 per cent.) required to gain a certificate on the results of the three examinations. 111 first class certificates (for vocal or instrumental music) were granted, and 115 second. To take a first class certificate it was necessary to obtain 75 per cent. of the marks.

X.—Musical Education.

This is also a subject upon which the Council appointed a Committee. In the first instance, it was proposed to confine all the labours of the Committee to the consideration of the musical examinations of the Society; but the scope of its labours soon widened, and it appeared evident that a better result could be attained by elaborating a system which, provided the necessary means were forthcoming, might apply to the musical education of the whole kingdom. The Committee accordingly prepared an elaborate syllabus, founded on the Art Directory of the Science and Art Department. This, in their opinion, shows a ready means by which the present much-needed want of organisation in musical teaching might be remedied. It is a fact well known to all versed in such matters, that a sum of £119,000 per annum is paid by the Education Department, nominally for instruction in music; and it is also well known that no such instruction is really given. Even in the training colleges, where instruction is given, and the results properly tested by examinations, no certificate of proficiency is granted, and no means exist by which qualified teachers may be distinguished. In schools aided by the Government grant, there is neither genuine instruction nor examination worthy the name. If the Government could be induced to apply the large sum above mentioned for the national culture of music, beginning with elementary schools, in the manner suggested by the programme drawn up by the Committee, the Council think that this difficult problem would not wait long for a satisfactory solution.

XI.—Artisan Reporters.

It was announced in the report of the Council presented to the Society last year, that H.R.H. the President of the Society had proposed to the Council that arrangements should be made to procure a series of reports by representative artisans on the Exhibition then being held in Paris, in the same way as had been done by the Society in 1867. At the time when the last year's report was issued the movement had been but recently begun; during the summer of 1878 it was carried to a successful issue.

As stated in last year's report, a Joint Committee was formed of members of the Royal Commission and of the Society of Arts. This Committee held many meetings, and under its directions arrangements were made for selecting a number of men, sending them to Paris, and receiving them there. The Committee also collected funds for the purpose of defraying the expenses of this movement. The result of the arrangement was that 204 artisans were sent over to Paris, most of whom have sent in reports; 57 of these men were sent at the expense of the fund; the charges of the other 147 were defrayed, some by provincial towns, others by various societies, others through their employers; whilst a few paid their own expenses.

In the arrangements made for the Reporters, the Committee were greatly assisted by the London, Chatham, and Dover, and the South-Eastern Railway Companies, who undertook to carry the men to Paris and back at a reduced rate. The London, Brighton, and South Coast Railway Company also made similar arrangements, and conveyed some of the later parties. The arrangements in Paris for the reception of the men were made under the special directions of Sir Philip Cunliffe Owen; two houses were engaged near the Exhibition for their benefit, and some rooms were also set aside for the purpose in one of the houses used by the Staff of the Royal Commission. The men were admitted free to the Exhibition, and were given every facility for the successful accomplishment of their task. They were also introduced to many of the best workshops and manufactories within reach of Paris. In all cases, it is pleasant to be able to say that the Reporters expressed themselves well satisfied with the arrangements made for their reception.

In all, 168 reports were received; some of these have already been printed by the towns who subscribed to send out the men; and five reports, made by the Reporters of the Coachmakers' Company, have been printed in a very handsome form by a late Master of the company, Mr. C. Sanderson. The other reports were carefully considered by the Committee, and it was eventually decided to make a selection from them, and publish the selected reports in classes, as well as in a single volume. In this undertaking the Committee have been greatly helped by the liberality of Messrs. Eyre and Spottiswoode, who have undertaken to print the reports at cost price; and

of Messrs. Sampson Low, Marston, Searle, and Rivington, who have undertaken, on being paid a certain sum towards the cost of printing, to publish the reports at their own risk. The reports are now passing through the press, and will appear almost immediately; most of them, indeed, are printed, and are only waiting for their final corrections.

The Joint Committee have made a report to H.R.H. the President, in which they give an account of their proceedings since the commencement; this report will shortly appear in the Society's *Journal*, as soon as it has been received by his Royal Highness.

In carrying the movement to a successful issue the Society is greatly indebted to those members of the Paris Commission who formed a Joint Com-Committee with the members of the Society's Council; and especially to Lord Spencer, the energetic Chairman of the Joint Committee. They also feel that the thanks of the Society are due to Sir Philip Cunliffe Owen, under whose careful organisation were made the admirable arrangements for the accommodation in Paris of the Reporters. The success of the movement is indeed largely owing to his energy, and the Council are glad to avail themselves of this opportunity for stating the fact. The funds provided came, to a large extent, from the liberality of several of the City Companies. The Clothworkers' Company contributed £100. The Drapers' and Mercers' 50 guineas each. The Fishmongers', Carpenters', and Salters' also subscribing liberally; the total amount thus provided was £741. The Council feel that this movement has been thoroughly successful, and this is the more satisfactory to them since it was initiated through the personal efforts of their President.

XII.—Swiney Prize.

The present year is the one in which the presentation of the Silver Cup, of the value of 100 guineas, together with a sum of money of equal amount, had to be made, under Dr. Swiney's will, to the author of the best published work on jurisprudence. The award is made jointly by the Society of Arts and the College of Physicians, and the custom has been to award the prize alternately for medical jurisprudence and general jurisprudence; this year it was the turn of medical jurisprudence, and the award was consequently made mainly on the recommendation of the College of Physicians. The joint committee of the Society and the College nominated Dr. Norman Chevers, to whom the award was made at a meeting of the adjudicators in January last, for his book entitled, "A Manual of Medical Jurisprudence for India." Dr. Chevers has accordingly received the money and the cup, which was executed by Messrs. Garrard, from a design made expressly for the Society by Maclise.

XIII.—Owen Jones Prizes.

The first award of the Prizes established by the Owen Jones Memorial Committee has been made during the present year. That Committee presented to the Society the sum of £400, the balance of subscriptions to the Owen Jones Memorial Fund, on the condition that the interest of this money should be expended in prizes to students of the Schools of Art, who should produce the best designs for household furniture, &c., on the principles laid down by Owen Jones. The examiners reported that the following students had sent in to the annual competition of the Science and Art Department, works of sufficient merit to deserve a prize:—John M. Carr, School of Art, Nottingham, design for a lace curtain; Frank Baker, School of Art, Nottingham, design for a lace curtain; Harry H. Hitching, School of Art, Nottingham, design for a wall paper; Arthur J. Sewell, School of Art, Nottingham, design for silk tapestry; Isabella C. Bergin, Metropolitan School of Art, Dublin, design for muslin; and I. S. Ingall, School of Art, Barnsley, design for modelling rosettes and ornamental borders.

The prizes consisted in each case of a well-bound copy of Owen Jones's "Principles of Design," and a Bronze Medal. For this purpose, a special edition of "The Principles of Design" was prepared, and the Council have to tender their thanks to the Institute of British Architects for permission to re-publish this work, which was originally a communication made by Owen Jones to the Institute. The republication was under the charge of Mr. Alan S. Cole, to whom also the thanks of the Council are due for the trouble he took in the matter.

XIV.—Saving Life at Sea.

It was also announced in last year's report that the Council had offered a Gold Medal for the best means of saving life at sea. In response to this offer a number of appliances were sent in and submitted to the Committee which had been nominated for the purpose by the Council. To this Committee, and especially to its Chairman, Admiral Ryder, the Council are indebted for an exhaustive and valuable report which has already appeared in the *Journal*, and has also been published separately. The medal itself was awarded to Messrs. J. and A. W. Birt, for the collection of buoyant articles sent in by them.

The Council are informed that the report is likely to be published as a Parliamentary paper, and it is unnecessary for them to add that this will afford them much gratification. Not only does such publication afford a testimony of the value in which the result of the labours of their Committee is held, but it will ensure the distribution of the report more widely than it could in any other way have been circulated.

XV.—Silversmiths' Work.

At the beginning of last Session a very liberal offer was made by Mr. E. J. Watherston, in the hope of improving the present style of workmanship in the precious metals in this country. Mr. Watherston placed at the disposal of the Society a sum of £100, to be offered as a prize for the best essay on the art of the silversmith. The proposal, as was announced in last year's report, was accepted by the Council, and the Society's medal added to the prize offered by Mr. Watherston. A committee was appointed, which drew up a set of conditions for the guidance of competitors. A circular, embodying these conditions, was accordingly published in December, 1877, and nearly a year later, in October, 1878, the date appointed, several essays were received. On one of these, by Mr. Herbert Singer, the committee considered that so much

research and labour had been bestowed that they recommended the Council to award to it the Society's silver medal and the money prize offered by Mr. Watherston. The Council have adopted the recommendation, and made the award accordingly. The essay strongly recommends the abolition of the duty upon gold and silver plate, and, further, that hall-marking should be voluntary, and not a compulsory proceeding. It may be added that the Committee of the House of Commons which, after sitting for two sessions has just reported, recommends that the duty should be abolished, as soon as the revenue permits, but approves the retention of the hall-mark. The Council have left it to Mr. Singer to publish his essay or not, as he thinks fit.

XVI.—Patent-law.

The members are aware that, early in the session, a Bill for the improvement of the law relating to Letters Patent for inventions was introduced by the Government in the House of Commons. As on former occasions, when legislative changes of this nature have been proposed, the Council felt it their duty to consider the matter, with the view of making any suggestions that might seem necessary to the promoters of the Bill; they accordingly appointed a Committee to consider the Bill, and if it appeared expedient, to prepare a memorial, which should be sent in to the Home Secretary. The Committee accordingly drafted a memorial, which the Council, after discussion, adopted, and sent in first to the Home Secretary, and afterwards to the Attorney-General, in whose special charge the Bill naturally lay. In this memorial, the Council expressed their feeling that the present Bill was a great improvement on those which had been brought forward in former sessions, and at the same time they pointed out what they considered would be further improvements, which they hoped the Government would see fit to introduce. At the time the memorial was sent in there seemed but small probability that the Bill would pass into law, and at the present date, it is almost certain that it cannot be passed; however, the feeling of the Council was, that this Bill being so great an improvement on former attempts in the same direction, it was probable that if some pressure were put upon Government, a still better measure might be introduced at some future period; they therefore felt it their duty to impress upon the Home Secretary the views they entertained. The report has already appeared in the *Journal*, but it may perhaps be desirable to summarise here the opinions expressed by the Council. The appointment of unpaid Commissioners is a proposal which the Council has always opposed when it was previously suggested, and which they still believe to be a most mistaken one. The question of opposition on open documents, a somewhat technical point, the Council thought was not clearly treated in the Bill, and they feared the introduction of a new and objectionable practice in this respect. They next referred to the uncertainty which, in some cases, attaches to the date of the patent, when more than a single inventor is seeking to patent the same invention, and showed that this uncertainty would be still further increased by the new measure. The proposed duration of the patent, which in the Bill is 21 years instead of 14, the Council are, on the whole, inclined to consider needlessly long. The clause referring to the question of compulsory licenses is, in the view of Council, certainly too stringent, and contains objectionable features; while they recommend that foreign inventions should be dealt with precisely on the same grounds as British. Finally, the Council confess they regard with very considerable distrust the extension of the existing powers of the Commissioners in the present Bill.

XVII.—School of Wood-carving.

A committee of the Council, appointed last summer, after having for some time considered how they could best utilise a sum of money offered to them by the Drapers' Company for the promotion of some branch of technical education, determined that this could best be done by founding a school of wood-carving in London, and in accordance with this resolution, the National School of Wood-carving was established in Somerset-street, Oxford-street. It appears to be a fact that this beautiful art, in which our countrymen once excelled, has long been languishing amongst us, and that we are further behind other countries in it, than in many other departments of decorative art. Very little good wood-carving is now produced in England, none of the highest quality, and when our architects and decorators require it, they are obliged to send their commissions abroad. Under these circumstances, it certainly appeared to the Council that a very promising field was open to the labours of the Society, and a most suitable one. It happened that there was in London at the time an Italian wood-carver of considerable eminence in the art, Signor Buletti, and the Committee recommended that an arrangement should be made with him to conduct a class in wood-carving. The proposal was laid before the Committee of the Court of the Drapers' Company, and was at once approved by them. A grant of £155 was accordingly made by that Committee for the purpose of establishing such a class. It was considered best, for various reasons, that this institution should be on a separate basis, and independent of the Society; and a Committee was, therefore, formed to carry on the business of the school, the Council undertaking to pay out of the funds given them by the Drapers' Company, the fees for eight students. The Committee consisted of Lieut.-Col. Donnelly, Mr. R. W. Edis, F.S.A., Mr. E. J. Poynter, R.A., Mr. W. Donaldson (of Messrs. Gillow's), and the late Mr. Le Neve Foster. To them was afterwards added Mr. W. Chapman, a member of the Court of the Drapers' Company, while on the decease of Mr. Foster, his place was taken by the present Secretary of the Society. Under their directions premises were engaged in Somerset-street, Oxford-street, and fitted as workshops, Signor Buletti being installed as instructor. Nine free students were nominated (one more than had been originally intended), and a few paying students also presented themselves. The school was opened in January last, and the funds in the care of the Society sufficed to cover the necessary expenses till the present date. The Council now consider that the school is so far established, that it can deal direct with its founders, the Drapers' Company, and they have therefore expressed to the Drapers' Committee, their hope that the Company will

continue their subscription to the school, paying it direct to the School Committee.

XVIII.—National Training School for Music.

During the year a movement of some importance has been on foot with reference to the amalgamation of the National Training School for Music and the Royal Academy of Music. As yet, however, no definite course has been determined upon, and the Council are not in a position to state what the results of the movement will probably be. The Training School itself has been going on satisfactorily and steadily. The funds provided have fully paid the expenses, whilst the scholars appointed have, in nearly every instance, justified their appointment. Since the last report five new scholarships have been founded, one of them through the agency of this Society.

XIX.—Universal Catalogue of Printed Books.

In January, 1878, H.R.H. the President of the Society referred to the Council the subject of the cost of producing a catalogue of all books printed in the United Kingdom, up to the year 1600. The proposal had been before his Royal Highness for some little time before, and the reference to the Council was merely upon the question of the cost of producing such a work, and was not made with any idea that the Society of Arts should bear the expence of so large an undertaking. In consequence of this communication, a Committee was appointed by the Council, and a number of questions issued to librarians, publishers, and others, seeking information on the subject; the Committee also held several meetings, and took the evidence persons conversant with the subject, amongst others, that of Mr. Bullen, the keeper of the printed books in the Museum. The conclusion arrived at by the Committee was that, before any such task could be attempted, as the preparation of a general catalogue of English printed books, though stopped at even so early a date as 1600, it would be desirable to print and publish the catalogue already existing in manuscript, in the library of the British Museum. The value of this catalogue as it now exists is admitted on all hands. Though it is not, of course, a complete catalogue even of English literature, it is the nearest approach to such a work existing, and it must of necessity form the base for the complete catalogue, whenever it may become practical to produce it. It appeared from the evidence of Mr. Bullen that the Museum catalogue would be ready for printing within two years, and the same gentleman gave it as his opinion that it would take five years to print. It was generally agreed by the witnesses that the printing of the British Museum catalogue would be highly desirable, for its own literary value, apart from its use as a book of reference to the contents of the Museum Library, and in this opinion the Committee cordially concurred. They accordingly reported in this sense to the President, and on receiving the announcement of his approval, they published their proposals, and issued a circular to printers and others, in order to ascertain definite particulars of the probable cost. The Committee had also a specimen page prepared in what would probably be the cheapest possible form. This page was sent round with the circular to a large number of printers, and the Committee have now under consideration the replies which many of the printers were good enough to send them. They hope shortly to be able to issue a second report, in which they would state further details of the cost of the undertaking, and what they consider would be the best way of carrying it into effect; in the meantime, they are glad to be able to say that the proposal they have made has met with the unqualified approbation of all the authorities on such questions, and that they have received great encouragement from numerous articles in the public press on the subject. The Committee, of course, have no idea that the Society should find funds for printing the catalogue of the Museum, but they hope to be able to lay their proposal before Government in such a form as to induce them to authorise the Trustees to undertake this important task.

XX.—Memorial Tablets.

During the year no additional tablets have been set up, but the Council have entered into communication with the Corporation of the City of London in the hope that the Corporation would assist the Society so far as regards the erection of memorial tablets within the City itself. They are glad to be able to report that the proposal, after full discussion in the City Lands Committee, was received most favourably, and they have every reason to expect that the Corporation will themselves undertake this portion of the work, thereby relieving the Society of Arts from a considerable part of its self-imposed task in the matter. The Council have, of course, undertaken to assist the City committee, and they feel much gratified at the cordial way in which their suggestions were received. When the result is seen of the action taken by the City of London, the Council will bring the idea before other large municipalities. By means of these tablets, reminiscences of the most remarkable persons in history will exist throughout the kingdom.

XXI.—Domestic Economy.

The second annual Congress on this subject was held at Manchester, in June last, under the presidency of the Duke of Westminster. The meetings passed off successfully, and attracted much interest. A report of the proceedings was published, partly at the cost of the Society, and partly at that of the Local Committee. In the opinion of the Council, the additional number of members joining the Society in consequence of its action in this direction not only repaid the cost, but increased the influence of the Society. Two other places contemplated the holding of a third Congress this year, but the present commercial distress induced them to postpone doing so.

XXII.—Drill in Schools.

The members are aware that for the past few years an annual drill competition was held by the London School Board, at which a challenge banner, presented by the Society, was competed for by schools of the London district. In 1878, owing to some alteration in the School Board arrangements, it was not found possible to hold this review, and, in consequence, the banner was not awarded. It now remains in the charge of the School Board,

who have informed the Council that they have under consideration fresh arrangements for the competition, which they believe will be satisfactory to the Society.

XXIII.—Australian Exhibitions.

A short time ago, a communication was received from the Royal Commission for the Melbourne and Sydney Exhibitions, asking if the Society had any works of art, or other objects of interest, which they could lend for the purposes of the Exhibition. As the members are aware, the Society is not rich in works of this character, but they had great pleasure in contributing the well-known picture by Barry, of the Temptation of Adam, at present on loan at the South Kensington Museum. They have also placed at the disposal of the Commission two sets of Barry's etchings, the same as those which are hung upon the walls of the staircase of the Society's house, in order that they might be shown at each exhibition, and afterwards be presented to some suitable institution in each city, to be nominated by the Commission.

XXIV.—Medals.

The Albert Medal, for "distinguished merit in promoting Arts, Manufactures, or Commerce," has this year been awarded, with the approval of H.R.H. the Prince of Wales, the President of the Society, to

Sir William Thomson, F.R.S., LL.D., D.C.L., "on account of the signal services rendered to Arts, Manufactures, and Commerce by his electrical researches, especially with reference to the transmission of telegraphic messages over ocean cables."

The Gold Medal, offered for the best means of saving life at sea, has been awarded to

Messrs. J. and A. W. Birt, "for the collection of buoyant articles sent in by them."

A Silver Medal has been awarded to

Mr. Herbert Singer, "for his essay on the art of the silversmith."

Silver Medals have been awarded to

Mr. F. Toplis and to Mr. Joseph Lucas, "for their papers containing suggestions as to the best means of dividing England and Wales into districts for the supply of pure water."

The usual Silver Medals for papers read at the evening meetings of the Society have been awarded as follows:—

To Mr. Alfred Haviland, M.R.C.S., for his paper on "The Distribution of Disease Popularly Considered."

To Mr. John Hollway, for his paper on "A New Application of a Process of Rapid Oxidation, by which Sulphides are Utilised as Fuel."

To Mr. Conrad W. Cooke, for his paper on "Edison's New Telephone."

To Mr. Thomas Wardle, for his paper on "The Wild Silks of India, especially Tussah."

To Dr. William Wallace, F.R.S.E., for his paper on "Gas Illumination."

The thanks of the Council were also voted to the following members of the Council who had read papers:—

To Mr. Hyde Clarke, for his paper on "Railways to Turkey and India."

To Dr. George Birdwood, C.S.I., for his papers on "Indian Pottery at the Paris Exhibition," and "The Quest and Early European Settlement of India."

To Mr. B. Francis Cobb, treasurer of the Society, for his paper on "Some Causes of the Recent Depression in Trade," and "Retrospect and Prospect in Egypt."

To Mr. W. H. Perkin, F.R.S., for his paper on "The History of Alizarin and Allied Colouring Matters, and their Production from Coal Tar."

As stated in the section of the report announcing the award of the Owen Jones prizes, bronze medals have been awarded to the successful competitors for those prizes.

XXV.—Foreign and Colonial Section.

The Council have had at various times under consideration the desirability of establishing a special section, at which questions relating to our colonies might be brought forward and discussed. The number of meetings which are held during the Society's Session is so great, that the Council have always doubted the expediency of increasing that number, and have not, therefore, thought it wise to add another to the Society's sections, successful as the work of those departments always has been. They have, however, now decided to adopt a middle course, by extending the scope of the African Section, and in future they propose to bring into this department questions relating to the Colonies, and to call the section the "Foreign and Colonial Section," instead of merely "African." During the six years of its existence, the African Section has been thoroughly successful; but it appears to be a question whether a smaller number of meetings devoted solely to Africa might not be sufficient, and whether three or four evenings could not be spared to the consideration of Colonial matters. The Council feel that in taking this step they are likely to add to the influence of the Society by attracting to it many old colonists and others interested in the colonies, now living in London, who they hope will come forward and support the movement.

XXVI.—Alteration of Bye-laws.

A Special General Meeting was held on the 16th June, at which certain alterations were made in the Bye-laws of the Society. The only important change was the addition of four to the number of vice-presidents, the new vice-presidents being nominated by the President. Formerly, the number of vice-presidents was 20; there may now be 24. Of these, 20, as hitherto, will be selected by the Council in the usual way, while a number not exceeding four may be nominated by the President of the Society. The other alterations were not of an important character, and were simply made because in revising the Bye-laws it was found that there were one or two minor points which appeared capable of improvement.

XXVII.—Finance.

With reference to this important section of their report, the Council have only to say that the financial condition of the Society is thoroughly satisfactory. The members are aware that, since 1875, the Society's accounts have been audited month by month by Mr. J. Oldfield Chadwick, the well-known accountant, who reports each month to the Council, and this arrangement is found in every respect a satisfactory one. During the pre-

sent Session also, the Council requested the standing Finance Committee to make a special examination into the financial state of the Society, and to report thereon. This Committee went carefully over the items of the expenditure of the Society for the past five years, and, after full consideration, presented a very satisfactory report to the Council. They found that the annual revenue of the Society during that period has amply sufficed for its annual expenditure, and that, while it has utilised all the funds it has received, it has not incurred any expenses which could not be met by the revenue of each year. In the annual income thus considered, the life contributions received in each year have not been included, as these are funded, to form a reserve available for such expenses as repairs to the premises, renewal of the lease, &c. The Council have every reason to expect that, during the coming session, they will be able to effect several economies in various departments of the Society's work, and they hope by this means to obtain fresh funds for the promotion of many of the objects which they have in hand. The usual accounts of the Society's receipts and expenditure, with the statement of assets and liabilities, have already been published in compliance with the Bye-laws in the Society's *Journal* of last week.

XXVIII.—Office Arrangements.

The death of Mr. Foster, of course, necessitated a rearrangement of the office of the Society. Acting on the Bye-law which empowers them to fill up vacancies occuring in their own body, or in the post of Secretary, the Council appointed Mr. H. Trueman Wood as Secretary. Mr. Wood has edited the Society's *Journal* since 1872, and has held the post of Assistant-Secretary since 1876. The Council consider that his experience under Mr. Foster fully qualifies him for the post of Secretary, and they have much pleasure in recommending him to the general body of members for election.

This appointment rendered it necessary to find some properly-qualified person for the post of Assistant-Secretary, who could, under the supervision of the Secretary, act as Editor of the *Journal*. For this post the Council selected Mr. Wheatley, the Clerk to the Royal Society. The Council think themselves fortunate in having secured the services of so thoroughly competent a gentleman, and they are glad to be able to say that, during the short time Mr. Wheatley has been in the service of the Society, he has fully justified their anticipations.

Mr. H. H. Room still continues to be the Accountant of the Society, and the Council have pleasure in testifying to the careful and satisfactory way in which he has, since his appointment in 1876, always discharged his duties.

Mr. Charles Critchett, whose health has been failing for some time past, took the opportunity of the changes in the Society's scheme of examination, consequent on the transfer of the Technological Examinations to the City Institute, to send in his resignation as Educational Officer. The Council, in accepting his resignation, have, as a recognition of his long services to the Society, had much pleasure in electing Mr. Critchett an honorary Life Member of the Society, under Bye-law 66; they have also nominated him a member of the Examination Committee. Mr. Critchett became Assistant Secretary of the Society in 1856, and held that office until 1869, in which year he exchanged the post for that of Educational Officer.

XXIX.—The New Council.

According to the provisions of the Bye-laws, a considerable proportion of the Council must consist of new members, and, in accordance with the rules, the outgoing Council has submitted to the members a balloting list with the full proportion of fresh names. His Royal Highness the President has availed himself of the recent change in the Bye-laws to nominate for election as Vice-Presidents of the Society his two brothers, H.R.H. the Duke of Edinburgh, and H.R.H. Prince Leopold. H.R.H. the Duke of Edinburgh would, by the action of the ordinary rule, have passed off the Council, but the members will be glad to see his name still upon the list under the new regulations. H.R.H. Prince Leopold has not previously been connected with the Society, but it is hoped that he will find much that is consonant with his own tastes in its work. In selecting the names of fresh members for recommendation, the retiring Council have endeavoured to secure that as many interests as possible should be represented in their body. Earl Spencer rendered most valuable help to the Council last year, as Chairman of the Committee on Artisan Reports. The Duke of Sutherland is known not only as a patron of the arts, but as an inventor himself of no small merit, while the names of these two peers are such as to add weight and influence to any body they may join. Dr. Siemens is amongst the foremost men of science in this or any other country. Mr. Stansfeld has done good service as president of the Society's annual conferences. Mr. Brassey most ably represents the greatest of British interests — the maritime. Mr. Bramwell has already served as a member of Council, and the active part he is now taking, as chairman of the committee of the City Institute, in promoting technical education, gives him, in the opinion of his colleagues, a fresh claim to the recognition of a Society such as this. The proposed new Members of Council, other than Vice-Presidents, are Lieut.-Col. Donnelly, Sir Philip Cunliffe Owen, Admiral Ryder, and Major-General Cotton. Colonel Donnelly and General Cotton have before served on the Council, and the members will remember that the latter, after being elected chairman, was forced by severe illness to resign. It is with sincere pleasure that his former colleagues look forward to having him again amongst them. Sir Philip Owen has made himself a reputation in three great countries besides his own, as chief executive officer in successive International Exhibitions. Admiral Ryder served most efficiently on the Society's Committee on Life-saving Apparatus, and the very excellent report of that committee was principally prepared by him.

Some few words too are due to those who, by the action of the Bye-laws, are obliged to retire from the Council this year. The services of some of these it will be hard to replace, but while the Council regret the loss, they feel fully assured that it is above all things important to introduce a considerable proportion of fresh members to the Council every year, and they therefore hold that no personal considerations should be allowed to interfere with the hard and fast rule made

to secure this end. There is, perhaps, no member to whom the Society owes more than Sir Henry Cole. Mr. Cassels is a main-stay of the Indian Section, which has also been much helped by Sir George Campbell. Mr. Hawes is a very old member of the Society and the Council. He acted as Chairman of the Council from 1863 to 1865, and again in 1867. In the Session also previous to the present one, he accepted the duties of Deputy-Chairman, when the Chairman, Major-General Cotton, was incapacitated by illness. Mr. Simon is one of the greatest authorities on subjects coming within the range of the Society's sanitary work. These are the retiring Vice-Presidents. The members of Council retiring are Colonel Sir E. DuCane, Sir Ughtred Kay-Shuttleworth, and Major Webber. The last named was forced to resign his seat in the Council on being attached to the staff of Sir Garnet Wolseley, and despatched on active service to the Cape. The others have, each in his own department, been of useful service to the Society. Mr. Bramwell also retires from the Council, but he has been placed on the list for election as a Vice-President.

XXX.—Conclusion.

Such is the record which the Council have to lay before the members of the proceedings of the Session. Whatever other criticism may be passed upon their work, they feel it will not incur the charge of lacking variety. They can also assure the members that what is here briefly summed up represents a great deal of genuine hard work on the part of those who have had to carry through so many and such varied tasks. The members of the Council feel that there rests upon them, both collectively and individually, no small responsibility for the safe government of the affairs of this ancient and honourable Society. Perhaps as good a proof as any of the interest which members of the Council take in their work may be found in the number and the character of the papers read by some of them before the Society this Session. Three members of the Council have each contributed two papers, a fourth has read one paper, and, besides these, the Society is indebted to a member of Council for an important series of lectures, furnished gratuitously, in continuation of a series of Cantor lectures delivered last Session. Perhaps many of the members hardly recognise the amount of gratuitous work done by the members of the Council. It is true that they one and all feel that they are only performing their duty, and that they esteem highly the opportunity given them by the members for performing that duty. Still, they think it due to themselves that the general body of members should be fully informed of the nature of the work carried on in the Council and the Committees, and should know that the body to whom they have delegated their authority is not inactive or inattentive to their work. And while it has been at once the pleasure and the duty of the members of the Council to devote their best energies to the service of the Society, there have yet been many subjects on which the Council have had to seek the aid of others outside their own body. In every case such aid has been been readily forthcoming, and to the generous and willing help thus afforded is due no small portion of the success attending the Society's work. That this work has been successful, and that the past year, like the many previous years which have seen the growing prosperity of our institution, will be fruitful of good result in the future, is the sincere conviction ef the Council. With the knowledge that they have done their best, and the belief that their efforts will be fully appreciated by their fellow members, they come forward to surrender their authority, and to ask that they may be once more entrusted with it for the coming year.

The Chairman then moved the adoption of the report, which was seconded by **Mr. J. A. Youl**, C.M.G.

Mr. Hale summarised the balance-sheet of the Society, and compared the various items with the corresponding entries of last year. He drew attention to the large expenditure during the last two years for repairs, which he put down as averaging £500 a year. On the whole he thought the financial state of the Society to be satisfactory. He hoped the Council would pursue a liberal policy, and would endeavour to grant all possible facilities to the members in the way of opening the library and reading-room, and providing more convenient lavatories, &c.

Mr. Christian Mast expressed his approval of the establishment of the practical examination in music, and suggested that it might be as well if the examination could also be made to include the theory also.

The Secretary stated that that very point was then under the consideration of the Council.

Mr. W. Haughton considered that the report should have been previously printed and taken as read. All the matter contained in it was already familiar to the members through the medium of the *Journal*. He thought that there was one point of importance in the alteration of the Bye-laws which had not been mentioned in the report, aud that was the omission of the clause empowering members to admit their friends to see the models, paintings, &c. in the Society's House during the day-time. He noticed that there had been a sale of stock to meet the expenses of repairs, but he was glad to see that this was counterbalanced by the funding of the life subscriptions. Before agreeing to a vote for the grant to Mrs. Foster, he would be glad to be informed if the financial state of the Society was really such as to warrant the vote.

The Chairman explained that as the ballot of election of officers had to be kept open for an hour, it had always been the practice to utilise that hour for the readiug of the report. The clause in the Bye-laws referring to the admission of the friends of members had practically become obsolete, since the Society had, many years ago, given up the holding of exhibitions, &c., and it was practically not acted upon. He need not say that any friends of members were always welcome to inspect whatever the Society might possess worth their examination. As to the financial condition of the Society, he could only say that it was thoroughly satisfactory; and as to the grant to Mrs. Foster, the natural reduction in salaries, consequent of the uew appointments in the office, would more than cover such a charge, to say nothing of several other economies which the Council had in view for the coming Session.

Mr. Ravenhill supported the report, which he thought a useful summary of the work of the Session, though it dealt with matters which had appeared in the *Journal*. He supposed few members had read all the report referred to, although the matter may have originally appeared in the *Journal*. With reference to the sanitary matters referred to in the report, he did think the Society should put their own house in order, as there was much which left room for improvement in the sanitary arrangements of the Society's House.

Mr. Campin took decided objection to one portion of the report. That referring to the action of the Council on the Patent Bill. He considered it was a matter for regret that the Council had expressed the opinion that a measure, to his mind so full of defects, as that Government Bill ought to be passed. He thought that the Council should not have acted on its own responsibility in so important a matter. The rest of the report he cordially endorsed, especially the portion referring to the grant to the widow of the late secretary.

Mr. J. Oldfield Chadwick explained some of the points which had been referred to by Mr. Haughton and Mr. Hale.

Mr. J. R. Taylor expressed his approval of the report referring to the grant to Mrs. Foster, and considered that it would be an actual disgrace to a society such as theirs if the grant were not carried unanimously. He also considered that it would be a great boon to the members if the library could be opened in the evenings.

Mr. Hyde Clarke said he felt sure the Council would appoint a committee to consider the question of the library, but at the same time he must remind members of the large expense attending such an alteration.

The Chairman undertook that such a committee should be appointed. He then put the motion for the adoption of the report, which was carried unanimously.

The hour during which the ballot is required to remain open having now expired,

The Chairman declared that the following had been elected to fill the several offices.

The names in *italics* are those of members who have not, during the past year, filled the offices to which they have been elected.

PRESIDENT.

H.R.H. the Prince of Wales, K.G.

VICE-PRESIDENTS.

H.R.H. the Duke of Edinburgh, K.G.	Earl Granville, K.G., F.R.S.
H.R.H. Prince Leopold, K.G.	Lord Hampton, F.R.S.
F. A. Abel, C.B., F.R.S.	Sir John Lubbock, Bart., M.P., F.R.S.
Lord Aberdare, F.R.S.	Lord Northbrook, K.C.S.I.
F. J. Bramwell, F.R.S.	Robert Rawlinson, C.B.
Thomas Brassey, M.P.	*C. W. Siemens, LL.D., F.R.S.*
Alex. H. Brown, M.P.	*Earl Spencer, K.G.*
E. Chadwick, C.B.	*Rt. Hon. J. Stansfeld, M.P.*
Lord Alfred S. Churchill.	*The Duke of Sutherland, K.G., F.R.S.*
Hyde Clarke.	The Duke of Westminster, K.G.
Sir T. Douglas Forsyth, K.C.S.I., C.B.	
Captain Douglas Galton, C.B., F.R.S.	

ORDINARY MEMBERS OF COUNCIL.

G. C. T. Bartley.	*Sir P. Cunliffe Owen, C.B., K.C.M.G.*
George Birdwood, M.D., C.S.I.	W. H. Perkin, F.R.S.
R. Brudenell Carter.	B. W. Richardson, M.D., F.R.S.
Major-General F. Cotton, C.S.I.	*Admiral. A. P. Ryder.*
Lieut.-Colonel Donnelly.	Erasmus Wilson, F.R.C.S., F.R.S.
Henry Doulton.	J. A. Youl, C.M.G.

TREASURERS.

B. Francis Cobb.	H. Reader Lack.

SECRETARY.

H. Trueman Wood.

The Chairman moved a vote of thanks to the scrutineers, which was carried unanimously.

The Chairman then proposed, pursuant to a resolution of the Council (May 12th, 1879):—"That a grant of £100 per annum be made to Mrs. Foster for her lifetime, subject to revocation at any future annual general meeting, upon notice being given to the secretary at least one month previous to such annual general meeting."

Sir Antonio Brady seconded the motion.

Mr. Scott Russell, F.R.S., heartily supported the motion, as one of the oldest members of the Society and of the Council, and as a predecessor of Mr. Foster many years ago; indeed, as one of those who were responsible for having originally selected Mr. Foster. He well knew Mr. Foster's admirable qualities, and he had watched him all through his work, and felt that it was impossible to give an estimate in words of the value of his services. Not a fortnight before his death he called upon Mr. Foster, and told him not to think he was not watching the work of the Society because he had not attended its meetings of late so frequently as of old, but that he had come to say that all the expectations and hopes formed by the Society when they first elected him had not only been fulfilled, but had been surpassed. He also approved of the wise precaution of the Council in having reserved the power of withdrawing the grant. He valued extremely high the services of their late Secretary He well remembered the advice he heard given by a very distinguished person to a young man who had lately been appointed to a secretarial office. It was that he should consider not his own interests, but the welfare of the institution with which he was associated, and he might feel well assured the institution would not forget him. Such was the system on which Mr. Foster had always acted, and now the time had come when the Society for which he had done so much was called upon to make a due return.

Capt. Bedford Pim, R.N., M.P., said he had come with great pleasure, specially to support the Council in the really excellent resolution put before the meeting to-day; he thought the Council had acted excellently in the matter, and hoped the annuity would be granted. He had belonged to a great number of scientific societies, but he had not found in any of the societies to which he belonged, a secretary more able, more amiable, or more courteous than the late Mr. Foster, and he therefore hoped the resolution would be carried unanimously.

The resolution was then put from the chair and carried unanimously.

Mr. Hale moved a vote of thanks to the Chairman, which concluded the business of the meeting.

CONVERSAZIONE.

The Society's *Conversazione* was held at the South Kensington Museum (by permission of the Lords of the Committee of Council on Education) on Wednesday last, 25th June.

The galleries containing the Raphael Cartoons, the Sheepshanks Collection, the William Smith Collection of Water-colour Drawings, the Dyce and Forster Pictures, the Collections of Paintings lent by Lord Spencer and by the Trustees of the late Rev. Pryce Owen, "The Chantrey Bequest," and the Schliemann Collection of Objects from Troy, as well as the courts and corridors of the ground floors, were open. The Reception was held in the Throne-room of Akbar Khan in the Architectural Court, by Lord ALFRED S. CHURCHILL, Chairman, assisted by the following Vice-Presidents and Members of the

Council:—F. A. Abel, C.B., F.R.S., E. Chadwick, C.B., Hyde Clarke, Robert Rawlinson, C.B., C. W. Siemens, LL.B., F.R.S., R. Brudenell Carter, Major-General F. Cotton, C.S.I., Henry Doulton, Sir P. Cunliffe Owen, C.B., K.C.M.G., W. H. Perkin, F.R.S., and B. Francis Cobb.

A Promenade Concert was given by the band of the Grenadier Guards (conductor, Mr. Dan. Godfrey), in the North Court, the following being the programme of music performed:—

Garrison March		Latann.
Overture	"Masaniello"	Auber.
Valse	"Pomone"	Waldteufel.
Selection	"Carmen"	Bizet.
Cornet Solo	"The Lost Chord" Mr. J. Pickup.	Sullivan.
"The Regimental March of the 24th Regiment."		
Selection	"Faust"	Gounod.
Valse	"Carmen"	Strauss.
Selection	"H.M.S. Pinafore"	Sullivan.
March of the Israelites	"Eli"	Sir M. Costa.
Pot Pourri	"Le Petit Duc"	Lecocq.
Galop	"Akrobaten"	Zikoff.

Vocal and instrumental music, consisting of glees, &c., was given at intervals during the evening, in the Lecture Theatre, by the Royal Criterion Hand-Bell Ringers, assisted by Miss Bessie Webber, Mr. Bevan, and Mr. J. A. Birch (H.M. Chapel Royal), under the direction of Mr. Harry Tipper. The programme was as follows:—

From 9 to 9.30.		
Bells	"Royal Criterion March"	Hill.
Glee	"'T was on a bank"	Hullah.
Bells	"Blue Bells of Scotland" with variations."	
Glee	"My Lady is so wondrous fair"	Calkin.
Bells	"Huntsman's Chorus"	Weber.
Part Song	"Hope will banish sorrow."	
Bells	"Imitation of Village Chimes."	
From 9.45 to 10.15.		
Glee	"The Bells of St. Michael's Tower"	Stewart.
Bells	"The Harmonious Blacksmith"	Handel.
Humorous Trio	"Maiden Fair"	Haydn.
Bells	"Rainbow Schottische"	Kleber.
Madrigal	"In going to my lonesome bed"	Edwards.
Bells	"March of the Men of Harlech"	
Choral March	"Come, merry comrades"	Becker.
From 10.30 to 10.50.		
Glee	"The Sands of Dee"	Macfarren.
Bells	"Scotch Airs"	
Part Song	"A Wife's Song"	Barnby.
Bells	"Weel may the keel row"	
Humorous Trio	"Dame Durden"	Harrington.
Bells	"Chanson des Cloches"	Planquette.

The number of visitors attending the *Conversazione* was 2,486.

EXAMINATIONS, 1879.

The list of successful candidates in the Examinations for the present year has been printed, and is forwarded to the Institutions in Union with the present number of the *Journal*. Copies will also be sent to the various Local Boards for the successful candidates.

The Technological Examinations for the present year having been carried on under the direction of the City and Guilds of London Institute for the Advancement of Technical Education, the results for the present year will not be announced by the Society. They will be published by the Institute as soon as they are complete.

CORRESPONDENCE.

INOXIDATION OF IRON.

In the absence of MM. Stoffel and Dodé in Paris, I venture to answer the kindly-put queries of Mr. Grosvenor in your issue of May 30, in reference to M. Dodé's patent for the above. Although I cannot pretend to any strictly scientific knowledge as to the matters in question, yet I presume that iron has something analogous to pores, being, like other metals, composed of atoms, which must have what physicists term "interstitial atomic spaces," but which your correspondent seems to doubt. The "homogeneous adherence" he refers to I presume to be the result of known affinities of iron and platinum, being, as I believe, the only weldable metals, which I take to mean that they adhere homogeneously, viz., without the interposition of a solder. Experience alone gives the exact test of relative adherence of platinum to polished steel as compared with cast iron. Your correspondent asks somewhat doubtingly whether cast iron has a fibre? To this I can hardly give a strictly technical reply, but good steel is said to have a "fibrous texture," and steel itself is a finer species of cast iron. Moreover, axletrees are said by engineers to lose "their fibre" by long use, and to become crystalline and brittle. Hence I presume that there is a "fibre." Again, he asks whether molecules of platinum are welded to each other? But a slight acquaintance with physics shows the absurdity of such a question, a recognised axiom being that molecules can never touch each other; otherwise, where would be the space for heat and electricity contained in all metals? Again, he asks, "Has the process no theory?" But an inventor cannot patent a theory; it is not his business to promulgate one, and it might have the effect of invalidating his specification. Again, he asks, in reference to coating iron, "What is the test of adherence?" I can only reply—adherence. Can he imagine any other? I need not occupy your space to answer other queries of a similar nature, as they apparently arise from your correspondent's doubts as to the porosity of metals, by which I am led to suppose that he has never seen the well-known air-pump experiment, in which water is made to "sweat" through the pores (if he will allow me to use the expression) of a hollow brass or copper ball. He ends by stating that he has seen a specimen of platinum-coated iron cleared in a few minutes by treatment with nitric acid, which I cannot doubt, if only once coated. But nitric acid is hardly the thing likely to be used with articles so coated, the object of the patent being to protect exposed iron surfaces from ordinary corrosive influences that so rapidly beget rust. I may say, however, that there are processes included in M. Dodé's patent which will enable iron to resist even nitric acid. Let me add, that there is a French patent, which your correspondent seems to doubt, and that most of the articles shown at the Society of Arts were done in France.

Charles Lempriere, D.C.L.,
One of the Directors of the Inoxidation and Platinum Coating of Metals Company.

18, Queen Victoria-street, E.C.

SANITARY INSPECTION AND NATIONAL WATER SUPPLY.

The correspondence published in the *Journal* of this week, between the Right Hon. James Stansfeld, M.P., and Mr. C. N. Cresswell, contains a proposal which may prove to be of very great value. Without offering an opinion as to the practicability of organising a "Sanitary Inspection and Classification Department" of the Society, I wish to make a few remarks on one

phase of the subject, to assist in ventilating it, which Mr. Stansfeld thinks so desirable.

As the success of the proposal would greatly depend on information obtained by inspection and inquiry, the method in which these are made would materially effect the result. I do not know whether Mr. Cresswell contemplates compulsory inspection; that might be possible in the case of buildings in course of erection, but it would hardly be effective where houses are undergoing partial repair, on account of the irritation it might cause to both owners and occupiers (whose respective interests, by the way, do not always coincide).

From personal experience in several instances of house-to-house inquiry, and inspection in matters somewhat akin to those now contemplated, I feel sure that facts may be elicited more readily, whether from the rich or the poor, by compulsory inspection; and in saying this I do not except the most degraded parts of London. There should, of course, be proper authorisation to inquire and (if the occupier be willing) to inspect premises. This will, I feel certain, be the means of obtaining the greatest amount of information with the least annoyance. Actual inspection in sanitary matters is frequently impossible without unreasonable discomfort to occupiers and cost to somebody, because it is the custom to put drains, cisterns, water-pipes, gas-pipes, &c., in accessible places. A question naturally follows, how can a certificate be given on information which may be incorrect? Some one, perhaps, may solve the difficulty.

The reliability of information given in answer to inquiries, I believe to be greater than most people might suppose, and though interested motives will frequently warp the truth, this is often, in house-to-house inquiry, open to detection and correction.

Mr. Cresswell apparently limits the granting of certificates to new houses, or those which have been repaired, but it seems to me that it ought to be within the scope of inquiry to include, if need be, adjoining houses, as it is quite possible for the insanitary condition of one house to be due to the adjoiniug house, even to its approved sanitary appliances; and the most satisfactory mode of collecting information would include a whole block of houses at once.

The great importance of the still larger subject of National Water Supply would, I am confident, be more apparent, if thorough inspection and inqniry was made in every house, in a few selected small towns and villages, as to their present state of supply, and the sanitary and other couditions immediately depending thereon, and, by so doing, additional light would be thrown on the facts of the actual requirements of the population.

Having been a member of the Society for many years, I am glad to find its public usefulness still on the increase, especially in advancing sanitary knowledge and practice. No doubt many of us are looking forward with much interest for the reply of the First Lord of the Treasury to the letter of our President, relative to the appointment of a Commission on the subject of National Water Supply. F. H. McLauchlan.

19, Dalyell-road, Stockwell, S.W.,
21st June, 1879.

DR. THORNE ON FILTRATION OF WATER.

Unwilling as I am to give my signature to any communication that might be construed as a commercial advertisement, I think I cannot, on account of their national importance, pass over certain remarks by Dr. Thorne, at the Conference meeting, on May 16th, which unfortunately, owing to absence, I was unable to attend. Dr. Thorne is reported in the *Journal of the Society of Arts* to have said, he felt "that filtration was, as a rule, at the best mechanical, and they had every reason to believe that the particles which gave rise to enteric fever would not be removed by mechanical filtration."

Dr. Thorne thus admits that there may be an exception to the rule laid down by him. Now, I ask, can any one call filtration mechanical, if he finds in the VI. Report of the Rivers Commission, p. 221, the following passage as the result of a large number of analysis of filtered and unfiltered water: "Under the influence of this material (spongy iron)," Thames water assumes the chemical character "of a deep-well water"? Similarly, you may read in the Registrar-General's report of January 6th, 1877 (p. 5 and 6), "It may be interesting for those who can afford the cost of domestic filters, to know that even this polluted water can be chemically purified by filtration through spongy iron." I may further refer to XIX. Army Medical Report, p. 170 and 171, "The water filtered (through spongy iron) shows no tendency to favour the growth of low forms of life, and may be stored with impunity." This statement is made in contradistinction to water which has been filtered through animal charcoal.

From a report of the Prussian Military Administration, dated May 11th, 1879, I translate—"Nevertheless, I cannot but attribute the prevention and non-recurrence of new cases of typhoid fever in a great measure to the improved state of the drinking water by the spongy iron filter." This report refers to the use of a spongy iron filter during an epidemic of typhoid at one of the fortresses at Coblenz.

I think I need not quote any other official evidence, and will only mention my own researches on the subject, which are published in the proceedings of the Royal Society, No. 180, 1877, and No. 186, 1878, aud in a paper read before the Society of Medical Officers of Health, on May 16th, 1879, as they strongly corroborate the inference drawn from the XIX. Army Medical Report, that the action of spongy iron is not only chemical but even physiological.

I submit that if Dr. Thorne had had this evidence before his mind at the time he made those remarks, he would have allowed me to claim an exception to the rule laid down by him in favour of spongy iron.

Gustav Bischof.

Analytical Laboratory, 4, Hart-street,
Bloomsbury, W.C., June, 23, 1879.

THE CONTACT OF CIVILISATION AND BARBARISM IN AFRICA PAST AND PRESENT.

Mr. Hutchinson, in his very able and interesting paper on "The Contact of Civilisation in Africa Past and Present," which appeared in your *Journal* of the 13th inst., has been led into a grave error as regards spirits, probably by his perusal of official documents; and my reason for troubling you with this is to prevent your readers being similarly misled.

At Lagos alone, he says, 1,849,921 gallons were received, "the value of which there was 1s. 10d. per gallon, the duty being 6d. per gallon," and he goes on and states that "the spirit was selling in Africa at twenty times its real value;" without inquiring what his "real value" is, allow me to show your readers how the case really stands. First let me state, as Mr. Hutchinson gives the exact quantities imported into West Africa during the four years ending 1875, that he probably obtains this total from the revenue returns of our settlements only, whereas there is no doubt whatever that far moro than the quantity on which duty is paid at our settlements finds its way into West Africa, and of which no account can be obtained. He very properly complains that this is permitted at Lagos through the passive unconcern of the Government. Spirits are chiefly taken to Africa from the Continent (where some of the largest shippers have just failed) in cases, most of which contain $1\frac{1}{2}$ gallons, in 12 bottles; the cost of such a case at Hamburg of usual quality averages 3s. 2d., freight and insurance, 10d., the duty at Lagos is 9d., which makes the nett cost price of such a case delivered at Lagos 4s. 9d. Such of the cases as

arrive at Lagos safe, without breakage or leakage, fetch there from the natives six "heads" of cowries; these "heads" are a mere measure of value for the exchange of cases of gin into produce, which at Lagos practically consists of palm oil, and palm kernels. For 320 gallons (old) of the former (the number that must be shipped at Lagos to deliver a ton nett oil here) 576 "heads" have to be paid at Lagos. The present market value of a ton of oil delivered to the buyers is here £28 15s.; caskage to put it in (which is given to the buyers in the £28 15s.) costs £3 7s. 6d.; to get the oil home only from Lagos, and realised, viz., for freight, insurance, discount, landing, brokerage, and delivering, costs £5 7s. 6d.; total, £8 15s.; leaving, as the returns for 576 "heads" paid for it in gin at Lagos, £20, or $8\frac{1}{4}$d. per head. For the case of gin which costs, delivered at Lagos, 4s. 9d. there, six heads are obtained there in produce, which produce, when realised here at the highest gross market price, and deducting only the actual lowest cost of getting it from Lagos here, netts here $8\frac{1}{4}$d. per head, and, owing to the disgracefully reckless way in which the trade is at present, and for some time past has been carried on at Lagos, the result to the merchant, if palm kernels be shipped instead of palm oil, is no better. Thus, for the case of gin which cost, delivered in Lagos, 4s. 9d., the merchant receives back here in produce, 4s. $1\frac{1}{2}$d., making an actual loss, so far, only of $12\frac{1}{2}$ per cent. on the bare exchange, or $7\frac{1}{2}$d. per case, besides the expenses of his establishments in England and in Africa, without interest of capital employed at great risk in very many ways; and, when houses are carrying on extensive shipments of all kinds with worse results, the wonder is, as it has long been, how they do it, and how much longer it can last. There is another statement in Mr. Hutchinson's paper, which, if unexplained, might be very misleading to your readers. He says that, in 1875, the value of "English produce" imported into Lagos was £459,737, and that the worth of the produce exported from there during the same year was £517,536. Now, the value, as "imported," is the invoice cost of the goods at their port of shipment, without freight, or any of the many heavy expenses incurred to get them there and exchanged into produce, being added, and the "worth" of the produce "exported" is the gross market value of in the European markets, without any deduction for either collecting or transmitting it to those markets. Edw. Banner.

London, 17th June, 1879.

GENERAL NOTES.

Patent Bill.—Mr. Anderson has given notice of motion in the House of Commons, on the second reading of Patents for Inventions (No. 2) Bill, "that, in the opinion of this House, no measure of change in the Patent Laws will be satisfactory to the country if it continues to treat inventors as public enemies to be impeded and heavily taxed, instead of legislating so as to stimulate the inventive genius of the nation to bring improved machinery and labour-saving appliances to the aid of our depressed manufacturing industries."

Yorkshire College of Science.—The Clothworkers' Company have voted £3,500., beyond the £10,000 previously voted, to cover the complete cost of that portion of the buildings of the Yorkshire College of Science, Leeds, which will be required for the teaching of the sciences applied to the textile industries and dyeing. They have further agreed to maintain the buildings and the operations in full effect for a period of five years from the 1st of January next, at a cost of £1,200 per annum.

Elephants for Africa.—Regarding the capture and utilisation of the African elephant in Africa as a means of transport, Dr. John Kirk, H.B.M.'s Consul-General, writes to a friend in this country from Zanzibar, under date the 3rd inst.:—"I have to thank you for the book just come about elephants. You seem to think I do not approve, or may not approve, of elephants being used. Quite the contrary. It is, in my opinion, a most promising experiment, and one I would take up until we knew the practical result. I would try the experiment fairly, and not give it up until convinced that it could not succeed. I hope, therefore, to see the elephants here soon. I think you forget that once I had an African elephant, now in India, that was quite tame. I am sure they can be caught and made use of. It only remains to know whether they will answer and pay, or whether the old way of transporting by porters is not, after all, cheaper. I have no other doubt. If elephants cannot be taught and tamed I shall be much surprised. I am sure they can, but if the practical difficulty begins, then the real experiment comes only after, and the point to decide is, will they pay? Not the first experiment, of course; but after the thing is in working order. I think, with you, that the north of Nyassa offers a good field for catching them. I should try to secure them when in the water. Livingstone and I once caught a calf in this way, and we might then have secured a full-grown animal in the Shire. When we passed first the animals were always in the water. Another way would be where there is no wood for fences strong enough to adopt the way used for hunting them in the centre of Africa, where I have seen it done in a clump of reeds a mile or two wide; the herd, once in, were surrounded, and the grass set fire to. As the animals tried to break out they were driven back. At last they became so blind with grass smoke, and distracted by the bursting of the canes under the heat of the fire that they were easily killed. I believe they might thus be caught.—*Globe.*

Population of Indian Cities.—British India has 44 cities counting 50,000 inhabitants and upwards, the most populous ones being—Calcutta, 892,429; Bombay, 644,405; Madras, 397,552; Lucknow, 284,779; Benares, 175,188; Patna, 158,900; Delhi, 154,417; Agra, 149,008; Allahabad, 143,693; Bangalore, 142,513, Umritsur, 135,813; Cawnpore, 122,770; Poona, 118,886; Ahmedabad, 116,873; Surat, 107,149; Barreilly, 102,982; Lahore, 98,924; and Rangoon 98,745.

NOTICES.

SANITARY CONFERENCE.

The Pamphlet containing a full report of the papers and proceedings of the late Conference on National Water Supply, Disposal of Sewage, and Health, will be published shortly, price 2s. 6d.

Applications for copies of the Report should be addressed to the Secretary.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

MEETINGS FOR THE ENSUING WEEK.

Wed., July 2nd...Central Chamber of Agriculture and Farmers' Club (at the House of the Society of Arts), 4 p.m. Conference on the Practical Remedies for the Present Depression of Agriculture.
Entomological, 11, Chandos-street, W., 7 p.m.
Obstetrical, 53, Berners-street, W., 8 p.m.

Thurs., July 3rd...Archæological Institution, 16, New Burlington-street, W., 4 p.m.

Fri., July 4th...Geologists' Association, University College, W.C., 8 p.m.

JOURNAL OF THE SOCIETY OF ARTS.

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FRIDAY, JULY 4, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

CHAIRMANSHIP OF THE COUNCIL.

On Monday last, at their first meeting after the Annual Election, the Council chose Lord Alfred S. Churchill as Chairman for the ensuing year. The various Committees were also re-appointed.

SOCIETY OF ARTS EXAMINATIONS.

Report of the Educational Officer.

To the Council of the Society for the Encouragement of Arts, Manufactures, and Commerce.

Gentlemen,

The examinations in the Technology of Arts and Manufactures, one of the most important branches of the Society's educational operations, having been this year transferred to a new but influential body, the City and Guilds of London Institute for the Advancement of Technical Education, I have taken the opportunity of this change to tender to the Council my resignation of the office of Educational Officer, a step which my very indifferent health has led me to contemplate for some time past. Before commencing my report, I may, perhaps, be allowed to express the deep regret with which I thus sever my official connection with the Society—a connection which has lasted for twenty-three years—and my sense of the honour the Council have conferred upon me in electing me a life member of the Society, and in nominating me a member of the Education Committee.

The transfer I have above referred to, naturally deprives this report of much of its usual interest, and before entirely dismissing the subject of the Technological Examinations, I think it right briefly to place on record here the following facts in reference to them. They were originated by a member of the Council, Colonel (then Major) Donnelly, R.E., now Director of the Science Division of the Science and Art Department at South Kensington, and were inaugurated in 1872, at a conference, presided over by H.R.H. the Duke of Connaught, then Prince Arthur. They were first held in 1873, in which year there were five subjects —Cotton Manufacture, Silk Manufacture, Paper Manufacture, Steel Manufacture, and Carriage-building. In 1874, the five subjects above mentioned were retained, with the addition of four more, Cloth Manufacture, Glass-making, Pottery and Porcelain, and the Manufacture of Gas. In 1875, five more were added, Agriculture, Silk Dyeing, Wool Dyeing, Calico Bleaching, Dyeing, and Printing, and Alkali Manufacture. Agriculture was omitted on its being included in the list of the subjects of the Science and Art Department Examination.

In the first year, with five subjects, three of them were taken up, the number of candidates being only six. In the second year, with nine subjects, five of them were taken up, and the total number of candidates increased to thirty-six; in the third year, with fourteen subjects, eight of them were taken up, and the number of candidates advanced to forty-six; in the fourth year, seven subjects were taken up by sixty-two candidates; and in the fifth year, eight subjects by sixty-eight. Last year the subject of Telegraphy was added, and there were seven subjects taken up, the number of candidates having advanced to one hundred and eighty-four. I may mention that this large increase was, to a great extent, due to the fact that payments to the teachers were made on results (as at the Science and Art Department), the funds being liberally furnished to the Society for this object by the Worshipful Company of Clothworkers, who have been most prominent in their support of technical education for several years past. The results of this year's Technological Examinations will, doubtless, be published by the above-named Institute as soon as they are arrived at.

With regard to the General Examinations, I am happy to be able to report a further increase in the number of candidates. This year there were 1,494 examined as against 1,330 last year, 1,185 in 1877, and only 974 in 1876. Of these, 1,009 passed, and 485 failed, the corresponding numbers last year being 902 and 428. The number of papers worked was 2,302, as against 2,094 in 1878, but the number of First-class Certificates is only 433 as compared with 468 last year, showing that the proportion of highly meritorious candidates has considerably diminished. The number of Commercial Certificates awarded is 77, as against 70 in 1878.

With regard to the subjects, I may say that in most of them the increase in numbers has been but slight, and in four of them, Book-keeping, Commercial Geography and History, French, and Spanish, there has been a falling off. The most marked increase is in the Theory of Music, which attracted only 166 candidates last year, while this year 288 appeared. There has also been a decided increase in the numbers coming up for the Domestic Economy subjects, and this year for the first time candidates have come forward in the subject of Fine Arts applied to Industries. The number of prizes awarded is not so large as last year.

The Prince Consort's prize of twenty-five guineas, graciously placed by her Majesty at the Council's disposal each year, has been awarded to Frederick John Arnold, of the Birkbeck Literary and Scientific Institution, who obtained nine First-class Certificates with three prizes during the specified period. I may mention that another candidate, William C. Hudson, of the Liverpool Institute, obtained the same number, but the relative merits were decided by the Council in the same manner as on former occasions. The last-named candidate can, however, carry forward his certificates to next year, they having all been gained during the past three years.

The Council Prize (for female candidates) of ten guineas has been awarded to Ada Frances Webb, also of the Birkbeck Literary and Scientific Institution, and of the College for Working Women, Fitzroy-street, who has obtained three First-class Certificates in the specified period. There were several other female candidates who obtained the same number of Frst-class Certificates, but they were either disqualified in accordance with the regulations stated in the programme, or they did not, on the whole, reach so high a standard as the one to whom the prize has been given.

One of the most noteworthy features this year has been the practical examinations in Music. These examinations had appeared in the programme, but hitherto no sufficient number of candidates came forward at any one centre to justify the Council in sending down an examiner. This year, however, a most important beginning has been made, and it may be safely predicted that, if these examinations are continued, they will in the future become one of the most important branches of the Society's educational system. Centres were formed at Glasgow and Birmingham, the number examined being 64 and 29 respectively. It was afterwards found that there were many candidates in and near London who were desirous to have their musical powers thus tested, and the large number of 117 came up for the Examination, which was held on the 16th June and two following days. The Examiner's report is decidedly favourable. To these candidates, some of whom were examined in both divisions, no less than 111 First-class and 115 Second-class Certificates (for vocal or instrumental music) were awarded. I may mention that, as in the other Examinations of the Society, 75 per cent. of marks gives a First-class, and 50 per cent. a Second-class.

I have the honour to be, Gentlemen,
Your obedient servant,
Charles Critchett, *Educational Officer*.

EXAMINERS' REMARKS.

The Examiner in *Arithmetic* says:—"While, on the whole of the papers, there is a marked advance in intelligence on previous years, many of them are of rare excellence."

The Examiner in *Political Economy* says:—"The answering of the two best First-class candidates was remarkably good; that of all placed in the Second-class was, at least, respectable, but there was much answering of a low quality on the part of the majority of those who are classed as 'not passed.'"

The Examiner in *Commercial Geography and History* reports steady progress in both subjects, but more particularly in the latter. The paper to which the highest number of marks has been awarded in the First-class is an exceptionally good one. The one that stands second on the list is also excellent. The failures among the First-class amount to 23 per cent. Among the candidates for a Second-class Certificate there has been no failure this year. The work done is above the average.

The Examiner in *English* says:—I have taken a very

TABLE I.

Number of Papers Worked in each Subject in the Present and Three Past Years, with the Results for the Year 1879.

SUBJECTS.	1876.	1877.	1878.	1879. No. of Papers Worked.	1879. No. of First-classes obtained.	1879. No. of Second-classes obtained.	1879. No. of Papers not passed.
Commercial:—							
Arithmetic	518	524	579	595	115	186	294
English	333	366	428	459	20	370	63
Book-keeping	325	339	325	317	60	112	145
Commercial Geography and History ..	11	31	92	59	33	17	9
French	157	123	147	124	20	34	70
German	30	30	32	36	15	11	10
Italian	5	6	7	9	2	4	3
Spanish	9	7	24	12	3	3	6
Political Economy	17	24	46	50	10	16	24
Shorthand	66	77	74	87	5	27	55
Domestic Economy:—							
Clothing	10	16	28	68	14	31	23
Cookery	10	26	53	64	21	36	7
Health	8	35	60	73	7	20	46
Housekeeping and Thrift	9	17	29	58	23	24	11
* Theory of Music	..	155	166	288	84	117	87
Fine Arts	..	..	..	5	..	3	2
Museums	..	..	4	4	1	2	1
Totals	1,508	1,776	2,094	2,302	433	1,013	856

* This subject was omitted in 1876.

lenient view of the minimum of knowledge for which candidates may be allowed to pass."

The Examiner in *French* says:—"It affords me sincere pleasure to be able to state that the French papers this year, taken as a whole, are by far the best I ever remember seeing in connection with the Society's examinations. I have so often of late years been compelled to call attention to, what seemed to me, a lamentable want of systematic study and earnest preparation among the majority of candidates, that it is most gratifying to have to record my perfect satisfaction with the character of the work submitted to my inspection this time. Of 124 papers I find 20 entitled to a First-class and 34 to a Second-class Certificate. There remain 70 candidates not passed, a figure perhaps still proportionately too large even for a subject where accuracy is so hard to attain, but of these 70, I am happy to say that no less than 57 have secured from 49 to 30 marks, leaving only 13 below what used to be the minimum required for a third class certificate; so that these 57 candidates may

TABLE II.

RESULTS OF THE EXAMINATIONS OF 1879.

NAME OF LOCAL BOARD.	No. of Candidates examined.	No. of Candidates who passed.	No. of Unsuccessful Candidates.	No. of Papers worked.	No. of First-classes obtained.	No. of Second-classes obtained.	No. of Papers not passed.	No. of Commercial Certificates awarded.	No. of Prizes awarded.
Aberdeen	78	62	16	96	16	54	26	2	1
Aldershot and Farnham district	12	11	1	24	2	13	9	...	...
Aspatria	5	4	1	13	...	8	5	...	...
Bacup	15	9	6	28	...	17	11	3	...
Belfast	13	10	3	21	6	7	8	...	...
Birmingham, High School	14	11	3	27	2	14	11	2	...
,, and Midland Inst.	99	64	35	108	21	50	37	2	4
Blackburn	16	6	10	16	2	4	10	...	...
Bolton, Mechanics' Institution	8	3	5	10	1	4	5	1	...
Brighton	10	7	3	10	2	5	3	...	...
Burnley	28	14	14	35	6	12	17	...	...
Cardiff	14	5	9	26	2	8	16	...	...
Carlisle	45	37	8	64	14	41	9	4	...
Carmarthen	2	2	...	2	1	1	...	...	...
Crewe	3	3	...	8	2	3	3	1	2
Devonport	14	13	1	14	13	...	1	...	...
Dublin	1	1	...	1	...	1	...	...	...
Dudley	9	6	3	18	2	10	6	2	...
Dundee	14	10	4	24	5	11	8	2	...
Gartsherrie Academy	43	16	27	43	...	16	27	...	...
Glasgow, Anderson's University...	73	58	15	77	29	32	16	...	...
,, Assoc. for the Higher Education of Women ...	57	36	21	62	11	28	23	...	1
,, Athenæum	58	32	26	58	9	22	27	3	1
,, United Young Men's Christian Assoc. ...	49	23	26	54	2	24	28	...	...
Huddersfield	23	18	5	44	7	16	21	...	2
Hull, Church Inst.	1	1	...	1	...	1	...	...	...
,, Young People's Inst.	71	37	34	101	9	41	51	1	...
Ipswich	3	1	2	3	1	...	2	...	...
Leeds, Young Men's Christian Assoc.	41	27	14	71	11	30	30	3	...
Leicester	30	15	15	34	...	15	19	...	...
Liverpool Inst.	20	16	4	34	10	16	8	3	...
London, Birkbeck Inst.	120	102	18	221	93	87	41	10	17
,, Bow and Bromley Inst.	4	3	1	4	1	2	1	...	1
,, Camberwell Greencoat School	10	9	1	26	10	11	5	5	2
,, City of London College...	83	63	20	140	29	67	44	8	2
,, College for Working Women	14	8	6	20	...	10	10	...	...
,, Holloway College	23	20	3	53	2	27	24	...	...
,, Islington Youths' Inst.	27	13	14	37	3	13	21	...	...
,, Kentish-town Literary Inst.	1	1	...	3	1	1	1	...	...
,, Primrose-hill Educational Board	2	1	1	2	1	...	1	...	...
,, Quebec Inst.	4	1	3	5	2	...	3	...	1
,, Polytechnic Inst.	7	5	2	11	1	5	5	...	...
,, St. Stephen's (Westminster) Evening Classes ...	25	13	12	50	7	12	31	...	1
,, Walworth Literary Inst.	18	11	7	32	7	9	16	...	1
Macclesfield	2	2	...	4	1	2	1	...	...
Manchester	64	50	14	113	36	48	29	6	2
Milton Mount College...	76	70	6	217	31	120	66	9	2
Mossley	9	2	7	11	1	2	8	...	...
Oldham, Lyceum	50	24	26	83	7	27	49	4	...
Penzance	10	10	...	19	1	13	5	...	...
Preston (Avenham Inst.)	1	1	...	3	1	1	1	...	...
St. Helen's, Science Classes	7	5	2	9	1	5	3	...	...
Salford	25	16	9	40	2	21	17	1	...
Shipley (Salt Schools)...	4	4	...	8	3	4	1	2	2
Stourbridge...	13	5	8	19	2	5	12	...	...
Swindon	15	8	7	26	3	11	12	1	...
York	11	4	7	19	1	6	12	2	...
Totals	1,494	1,009	485	2,302	433	1,013	856	77	42

Number of Local Boards, 57.

be said, in the phraseology adopted in some university examinations, to have 'satisfied the examiner,' and under the old system, I should have been able to recommend as many as 111 candidates altogether for certificates out of a total of 124—a result never approached in former years, when the standard was, on the whole, rather below what I think it right and fair to make it now."

The Examiner in *German* says:—"I am happy to be able to state that I consider the result of this year's examination an improvement on that of last year. There were less failures this time, and more candidates passed in those classes in which they desired to obtain a certificate. Most failures were caused by the inability of the candidates to read the German *fac-simile* letters, which showed that they could not discharge the principal function of a German correspondent in this country, which consists in reading and translating correctly the commercial letters sent here from Germany. I should, therefore, advise intending candidates to have, before all, as much practice as possible in reading various German handwritings, and to make themselves, at the same time, fully acquainted with the terms and phrases current in German commercial correspondence."

The Examiner in *Italian* says:—"I find an improvement on last year's examination papers. Much care has been taken by the candidates generally in answering the questions, and in a few instances considerable preparation is shown, grammatical, commercial, and idiomatic knowledge being fairly evident. One or two candidates, apparently by what they have done, could have obtained a much higher number of marks, and probably a First-class, had they worked out all the questions. It is essential that candidates should understand that the whole set of questions must be answered if they aim at a First-class Certificate."

The Examiner in *Clothing* says:—"The competency in answering the questions is quite as high as last year, but the low average of the marks is due to the badness of the paper, and particularly of the sketched, patterns. Of the 66 competitors, only one has sent in a tolerable pattern of one garment. I regret to find, that as I feared, the now prevalent practice of teaching cutting out upon geometrical principles, has done more harm than good. Or can it be that the squared paper supplied to the competitors has encouraged them to construct the bad and utterly useless diagrams sent in with almost every paper. Some few have misunderstood the instructions as to working the clothing papers, and have sent in no patterns at all, which of course puts them out of the competition."

NATIONAL WATER SUPPLY.

SUGGESTIONS FOR DIVIDING ENGLAND AND WALES INTO WATERSHED DISTRICTS.

Essay by Frederick Toplis.

Motto—"Better late than never."

AWARDED A SILVER MEDAL.

If it were possible to start completely *de novo*, it would be a comparatively easy matter to arrange a system of water supply for England and Wales, which would provide a reasonably pure water for all existing towns and villages, and which would be capable of extension as fresh villages sprang up, and as towns grew and expanded. No scheme, however, can be considered satisfactory which does not take into account the large amount of capital already expended on water-works, and does not utilise, as far as possible, all existing works for water supply. There are enthusiastic reformers among us who say that everything, or almost everything, done up to this time is wrong; that the water supplied, for the most part, is impure and unfit for consumption; and that we must ignore all that has been as yet done, and make a fresh start. One would have us get all our water from the chalk formation, and assures us that there is an inexhaustible supply there, sufficient to provide every town and village in England and Wales with an unlimited amount of the purest water. Another would persuade us that this water is too hard to be fit either for use by the manufacturer or for domestic purposes, and that the wells already sunk in the chalk are slowly, but surely, draining it dry, and that we ought to go for our supply to the upper courses of the rivers and streams. A third, again, has a preference for gravitation schemes, as they are called, and would construct enormous reservoirs in the mountainous districts of the north-west of England and of Wales, and supply the whole country from these.

The Royal Commissioners on Water Supply, in their report issued in 1869, went very fully into the question of the water supply to London, but declined to go into the larger questions of the supply to provincial towns, or of the gathering grounds in various parts of the country generally available for water supply, giving as their reason that the inquiry must be one of great magnitude, involving a large amount of statistical and topographical investigation extending over the whole kingdom. The Commissioners, however, state in decided terms their opinion that no town or district should be allowed to appropriate a source of supply which naturally belongs to a town or district nearer to such source, unless under special circumstances which justify the appropriation; that when any town or district is supplied by a line of conduit from a distance, provision ought to be made for the supply of all places along such line; and that, in the introduction of any provincial water Bill, attention should be drawn to the practicability of making the measure applicable to as extensive a district as possible. These recommendations ought to form the basis of the future policy of all water legislation, and for the proper carrying out of them the following conditions seem to the author to be absolutely necessary.

1. That the country should be mapped out into watershed districts, each containing one or more complete river basins, and that a body of commissioners should be appointed to each district. These commissioners should be nominated by Government with the sanction of Parliament; they should be men not connected with the district by personal residence, nor by having property or business in the district, and their appointment should be for life, or at any rate for a long term of years, otherwise they will not take sufficient interest in their work to acquire a thorough knowledge of it. A man appointed to a post for a year or two rarely cares to go through the drudgery necessary to make himself acquainted with all the petty details connected with it.

2. That these Commissioners should be assisted by competent legal and engineering advisers. They should have a permanent engineer, at a salary sufficient to secure a man of considerable experience in hydraulic engineering; and there should be a

Map of Districts proposed by Frederick Toplis.

consulting engineer chosen from the first rank of engineers engaged in this class of work. It may, however, be left undecided for the present whether each set of commissioners should have its own consulting engineer, or whether two or more districts should be grouped together, or whether there should be only one, or perhaps two, consulting engineers for the whole of England and Wales.

3. That these Commissioners should have charge, not only of the waterworks in their district, but also of the rivers and other watercourses, and, in

fact, that every drop of water falling in their district should be more or less under their control, from the time it falls on the land until it reaches the sea. All existing Commissioners for river improvements, &c., must be abolished, and their authority merged in that of the new Commissioners, whose duty it would henceforth be to initiate and carry out works for the improvement of river navigation, for the prevention of floods, &c.

4. The Commissioners must have power to acquire all existing waterworks, and, if necessary, all canals, &c. With regard to canals, it will not, perhaps, be advisable that the Commissioners should acquire them except when, owing to the scarcity of water in a district and to the smallness of traffic on the canals, it may be considered advisable that they should be closed.

There are, no doubt, cases where the canals are fed with water which might be used as a source of supply to towns and villages, and there may even be cases where the canal itself might be used to convey the water to the towns, care being taken to cleanse its bed, to stop all pollution of the water for the future, and to discontinue the traffic. In other cases, again, canals might be used as flood channels, the locks being removed, and weirs, or sluice gates, substituted. Many of the canals have been purchased by the railway companies, solely for the purpose of preventing competition, and there would probably be little difficulty in acquiring these from the railway companies; but, in all cases where the abundance of water in the district, and the largeness of traffic on a canal, justify its being kept for traffic, it would not be desirable that the Commissioners should acquire it, but only that they should have control over it, to prevent the waste of water, or the increase of floods, or the pollution of rivers by the introduction of impure water from the canal.

The time is drawing near when it will be found absolutely necessary to appoint a Minister of Health, with an adequate staff, and he should have control, not only over the above suggested Commissioners, but also over all sewage authorities, and over all manufactories which pollute the air, and, in short, it should be in his charge that neither the water nor the air of the kingdom should be unnecessarily polluted. No doubt he would have other duties which, however, do not concern this paper. It is not intended that the Commissioners of Water Supply, which it is suggested should be appointed, should have charge of the sewerage arrangements of the districts. These may remain, as far as the present paper is concerned, under the existing authorities, although, no doubt, it will be desirable that a similar scheme to the present should be arranged for the creation of Commissioners of Sewage, and it will simplify matters if the jurisdictions of the two sets of Commissioners are conterminous. It must, however, be urged that it is advisable that these two bodies, the one charged with keeping all the water in the district as pure as possible; and, the other, with purifying as far as possible that portion of the water of the of the district which has necessarily been polluted, should be quite distinct, and that their engineers and consulting engineers should be different. It will the author thinks, be admitted that the Commissioners of Water Supply will be much more likely to guard the rivers jealously from pollution if they have not themselves the task of purifying the polluted waters of the sewers.

Both sets of Commissioners would be under the proposed Minister of Health, who would decide any controversies between them. It would be wise not to continue the piece-meal legislation which has hitherto prevailed in England in reference to water supply, and instead of, as some may be disposed to suggest, creating a set of Commissioners in one district where the question of water supply is most pressing, and afterwards enlarging the district and then creating another, and so on, it would be wise to at once map out England and Wales into districts. There has been, it is believed, a great deal of information collected by the Ordnance and Geological Survey Departments in connection with the existing and possible water supply, and it seems reasonable to expect that, if a Royal Commission were appointed to collect evidence and draw up a scheme, its labours would be finished in a short time. This Commission would, of course, include those Government officials whose duties have enabled them to gain information on the subject of water supply—such as the Directors of the Ordnance and Geological Surveys, and the engineers of the Local Government Board; and also several independent engineers of eminence in this branch of the profession.

The duties of this Commission would consist rather in arranging and utilising the vast store of information already collected by previous Royal Commissions, by the Survey Departments, and by private engineers, in the course of their practice, than in making fresh analyses or taking fresh evidence. The work of the Commission might be brought to a close at the end of one, or at the utmost two years, and the evidence it would collect would be of great service to the Commissioners afterwards appointed.

The next stage would be for Government to introduce a Bill to create the districts and appoint Commissioners, and there would be much less opposition if one general scheme were brought in, than if each district were taken separately. The Commissioners would choose their engineers, the Government appointing the consulting engineers. On the death or retirement of any of the Commissioners, the Government would appoint a successor.

The Commissioners should be instructed to proceed gradually, first acquiring a thorough knowledge of their district; then, proceeding to check all pollutions, to provide a water supply where none exists, to extend existing supplies, to improve the rivers, &c. They should be authorised to levy a double rate; one for the supply of water, it being understood that where a good supply at present exists the rates are in no case to be increased; and the other for the improvement of rivers and prevention of floods. It has hitherto been usual to levy rates for the prevention of floods only on the lands liable to be flooded; but the opinion is gradually spreading that, as the waters from the high lands contribute to the floods, and, as the water is poured off the lands much more rapidly than formerly, owing to the improved drainage, so it is only just that the high lands should contribute their quota to the rates, though not in as large a proportion as the low lands. It is estimated that, if this scheme were

carried out, it could be got into working order within five years of the present time, and that although there would still be much to be done, an end would have been put to the present state of confusion, and to the waste of money in Parliamentary contests between different towns, or even between different parties in the same town.

Now to consider in more detail the duties of the proposed Water Commissioners. They may be divided into :—

1st. Providing against the pollution of all springs, wells, water-courses, streams, lakes, and rivers; 2nd. Providing against floods, and storing water so as to maintain a sufficient flow in the rivers, in dry seasons, for the purposes of navigation, for water power, irrigation, &c. ; and 3rd. Providing a sufficient water supply of reasonable purity to all towns and villages in the district. These duties are taken in this order merely for convenience, not as in any way showing their relative importance.

1. *Providing against Pollution.*—This has hitherto been a very great difficulty, owing to the divided interests in the different river basins, to the persons charged with the protection of the rivers being local men, who are often themselves guilty of polluting them, and to the legal difficulties and expense. Some alteration would, of course, have to be made in the mode of proceeding against offenders, but it is out of the scope of the present paper to suggest what it should be. It may, the author thinks, be hoped that, under the new authorities, more success would be obtained than has yet been, as the whole of each water-shed would be under one charge, and the Commissioners would have no local interests to prejudice and hinder them in the fulfilment of their duties. The source of pollution may be divided into manufacturing, sewage, and agricultural. The question of the pollution of rivers was very fully discussed at the Conference at the Society of Arts, in December, 1874. Mr. John Thom, a calico printer, in a paper read at the Conference, stated that by purifying the waste water from his works, and preventing the pollution of the stream, he got a good per-centage on all the money spent, after having paid all working expenses. In many other manufactures the purification of the waste water would give an actual profit.

The removal of all sewage pollution from rivers is only a question of time. Many towns have already carried out efficient schemes of purification. Irrigation seems to have been the most successful plan, and might be more fully carried out if Commissioners of Sewage were appointed in each district, as suggested.

Agricultural pollution must always remain, and on this account, stream or river water, when there is any considerable extent of cultivated land in the basin draining into the river, can never be a desirable source of water supply for domestic purposes.

2. *Providing against Floods and Storming Water.*—This again, has, up to the present time, been very inefficiently performed, and, in fact, many of the works carried out for the improvement of rivers have been worse than useless. The River Nene may be taken as illustrating two great difficulties which at present lie in the way of all improvements. One, that a river basin is often under the charge of several distinct authorities; thus the main channel of the Nene is under five or more different authorities, besides which there are numerous others having jurisdiction over the banks, the washes, &c. The other, that one engineer after another is called upon to report on the state of a river, and each one thinks it necessary to differ more or less from his predecessors in his proposed works. About ten different reports on the River Nene have been made by eminent engineers since the beginning of this century, but the works proposed have either not been carried out at all, or else in a fragmentary and imperfect manner; and this river is still in a most unsatisfactory state.

The creation of one controlling authority in a river basin, with a permanent engineer, would, the author thinks, greatly facilitate the improvement of the river.

The Rivers Conservancy Bill, brought before Parliament this session, would, if passed, be an advance in the right direction, but there are several objections to it. The Conservancy Boards are not to be appointed at once over the whole kingdom, or even for the most important rivers, but the proposal to appoint a Board for any river is to originate with the landowners of the district. Another objection is, that a considerable proportion, if not the whole, of the members of the Board, are to be landowners of the district. The Thames and Lee are excluded from the Bill. Water-works and canals are not to be interfered with. It is doubtful whether, if this Bill were passed in its present form, the conservators would have full power to deal with all existing obstructions in rivers. Some of the authorities connected with the Nene and the Ouse, two of the rivers which most urgently require to be dealt with, have already protested against this Bill.

3. *Providing a Water Supply.*—This may be considered the most important of the duties of the Commissioners. They are to have power to acquire all existing water works, but need not acquire them if they do not think it necessary. In those places where the existing authorities are giving a good supply to their district from works in the district itself, there would seem to be no advantage in interfering with them. But in other cases, where water is brought from a long distance to a town, while places situated near this source of supply are very badly off for water, the Commissioners would take the works in hand, and enlarge them so as to afford a sufficient supply for the whole neighbourhood. In many cases now, towns fetch their water from a long distance, when abundant supplies of equally good or better water are near at hand. In others, they are content with impure water obtained in their neighbourhood, while, by combining with two or three adjoining places, they could bring pure water from a distant source with little increase of cost. Instances are given in the third report on Underground Waters, of the Committee appointed by the British Association, of places obtaining Acts to impound surface water from cultivated ground, when they could get an almost inexhaustible supply of pure water from shafts in the New Red Sandstone and Permian. All these mistakes could be avoided, if there were some central body in a large district having power to

acquire all requisite information, and to carry out all works necessary.

Before proceeding to describe in detail the districts into which it is suggested England and Wales should be divided, it will be as well to make a few remarks touching the quality of water desirable, the quantity necessary, and the quantity available.

The Quality of Water Desirable.—A great amount of information is contained in the 6th Report of the Rivers Pollution Commissioners, on the subject of the relative purity of the water from different sources; and the waters classified as wholesome are, first, spring water; secondly, deep well water; and, thirdly, upland surface water. The proposed Commissioners would, in selecting the best available water in each district, of course have some regard to the relative cost of the different supplies, and would not go to an immense expense to provide a first-class water (to use a convenient expression), when a second-class one could be obtained at a moderate cost; provided always that this second-class water is sufficiently wholesome and palatable.

The upland surface water, though not considered as wholesome as the deep well or spring water, is, however, generally softer, and is, therefore, more suitable for the manufacturing towns; and, although hard water can, as the Rivers Pollution Commissioners frequently state in their Report, be softened by Dr. Clark's process, yet this process must always cause considerable trouble and expense. Provided the upland water is collected from ground not cultivated, and that every care is taken to keep it free from pollution after it has been collected, there need not, the author thinks, be any hesitation in using it for domestic as well as for manufacturing purposes. Great difference of opinion exists among engineers and other experts, as to the purifying effect of the exposure to the atmosphere of a polluted stream, some thinking that, if sewage be poured into a river, the water, after flowing seven miles, will be as pure as it is above the source of pollution; others, that no appreciable purification would be effected; but most, if not all, will agree that water taken from a stream polluted by sewage at any distance, no matter how great, below the entrance of the sewage, is not desirable for domestic purposes; and considering the vast quantities of pure water hitherto unutilised that exist throughout the kingdom, it may be assumed that it only requires the creation of some central authorities, such as the suggested Water Commissioners, to insure the abandonment of all such polluted sources. The method adopted by the Rivers Pollution Commissioners of estimating previous sewage contamination is, the author thinks, an inconvenient and a misleading one.

The protection of the underground waters from pollution is a point which has hitherto been entirely neglected, but which urgently requires attention. The custom prevalent in many parts of the country, of pouring sewage into cesspools in permeable strata, or into what are known as swallow holes, is one which it will soon be found necessary to put a stop to.

The Quantity of Water Necessary.—The quantity actually supplied varies in different towns from 10 to 50, or even 100 gallons per head per day, but there is often a considerable waste. The quantity used in cottages is sometimes as low as two gallons per head, when the water has to be fetched, or five gallons when there is a supply close to the cottage. In larger houses, from 10 to 20 gallons per head is used. The average consumption of the manufacturing towns of Lancashire and Yorkshire has been stated by Mr. Bateman to be from 16 to 20 or 21 gallons for all purposes.

Experiments made show that not more than 10 or 11 gallons per head are actually used for domestic purposes, and the majority of the evidence collected on this subject seems to prove that 20 gallons, or at the most 25 gallons, per head per day, ought to be enough for all purposes.

The constant system of supply, properly carried out, is greatly preferable to the intermittent, and will soon, no doubt, become universal. Its introduction has in many towns been attended with a decrease in the quantity supplied, but this does not prove that less is usefully used, if the expression might be allowed, with the constant system than with the intermittent system. The reason for the decreased supply is simply that more care is generally taken to inspect the water-mains and the fittings in the houses, and to see that there is no waste of water. Such, however, is not always the case, as for instance, in London, where the water companies have in some parts introduced the constant system without any alterations being made in the fittings, the result being that there are cisterns overflowing day and night for weeks together, saturating the soil round the houses. It must be remembered that, while the supply for domestic purposes ought to be sufficient, any waste of water is a disadvantage to the householder and to the community. Under a properly managed system, the rates, where 25 gallons per day is supplied, ought to be less than where the supply is 50 gallons; and if in the latter case half is wasted, it is certainly not true economy to provide 50 gallons per head per day. Again, if the water running to waste enters the sewers, it has in many cases to be pumped up again; and if the sewage is used for irrigation, it is unnecessarily diluted by the waste water, and thus rendered less valuable. If the waste water does not enter the sewer, but penetrates the soil, it produces dampness, leading to discomfort and disease.

The use of meters for domestic as well as for manufacturing supply is sometimes advocated, but seems to the author unnecessary and unadvisable. If there were a proper system of house inspection, and if the inhabitants in a district were made to understand that waste of water would cause increase of cost of supply, and, therefore, increased rates, meters would be unnecessary; and if introduced, might often lead to an undesirable stinting of the water used in a household. The author, in his calculations, has assumed 25 gallons per head per day as the supply required, but thinks that it would be found that 20 gallons would be amply sufficient. He wishes to point out, however, that a much larger quantity than 25 gallons per head of the present population is available in each district. Assuming the population of England and Wales, when this scheme is put in operation, to be 27 millions, the quantity required will be 675 million gallons per day; and when this population has doubled, the quantity required, at the rate of

25 gallons per head per day, will be 1,350 million gallons per day, or 492,750 million gallons, say 500,000 million gallons, per annum.

QUANTITY OF WATER AVAILABLE.

The average rainfall throughout England and Wales is generally stated at 32 inches per annum, giving a total fall in the year of more than 27,000,000 million gallons; of this, the quantity given above, as required for a population of 54 millions, is less than 2 per cent. The direct collection of rain by each household for its own consumption has been advocated, but can only be carried out in country districts; and even there rain water could scarcely be classed as wholesome or palatable, as is shown by the analyses made for the Rivers Pollution Commissioners. The author thinks, however, that for the use of farming stock and agricultural machinery, rain water might and should be collected, and has, therefore, made no allowance for these purposes in estimating the quantity of water required per annum in England and Wales.

In the mountainous districts of the North-west of England, and of Wales, the rainfall is greatly in excess of the average, and, as the strata are impermeable, a large proportion of it runs off into the rivers and lakes; and the greater part of this water could be utilised, either by making impounding reservoirs, or by drawing off the water from the existing lakes.

In the central part of England, where the ground is of less elevation, and the rainfall not above the average, there is a very large area covered by the trias or new red sandstone formation. The Rivers Pollution Commissioners, referring to this, say that there is every reason to believe that vast quantities of hitherto unutilised water of most excellent quality is to be had, at moderate expense, from this very extensive geological formation. The committee appointed by the British Association state, in their second report, that "the area of New Red Sandstone is not less than 10,000 square miles in England and Wales, with an average rainfall of 30 in., of which never less than 10 in. percolates into the ground, which would give an absorption of 143,336,000 gallons per square mile per annum." This, over an area of 10,000 square miles, would give 1,433,360 million gallons, which is nearly three times the whole quantity that will be required for England and Wales when the population has doubled. In their third report, in 1877, the committee state that "there is an available daily supply from the New Red Sandstone and Permian of England of not less than 3,600 million gallons per day, remarkably free from organic impurity."

Further to the east is a band of Oolitic strata stretching from the north-east of Yorkshire to the south of Dorsetshire. The Rivers Pollution Commissioners say with reference to this formation, that "the oolites contain vast volumes of magnificent water stored in their pores and fissures;" and again that "the Oolites absorb immense quantities of rain water," and that "it cannot be doubted that a considerable proportion of this could be secured for domestic supply in its pristine condition of purity."

Further east again are the greensands and the chalk, which contain large bodies of water. In the fourth report of the Committee of the British Association it is stated that there are 26,687 square miles of Permian, Trias, Oolite, Hastings sand, greensand, and chalk, yielding subterranean waters. That "probably four-fifths of this area would yield unpolluted water, and would receive not less than from 10 to 15 inches annually, or a quantity, if six inches only were yielded in wells, of 240,000 gallons per day per square mile of surface, and in many districts double this, giving a total in England and Wales far in excess of that required for drinking and manufacturing purposes." 240,000 gallons per square mile over an area of four-fifths of 26,687 square miles, or 21,350 square miles, will give more than 5,000 million gallons per day. The quantity required for a population of 54 millions is given above, as 1,350 million gallons per day.

Further reference will be made to the available supply in giving the details of each district, but enough has been said to show that there need be no difficulty, in providing a good and sufficient water supply throughout England and Wales, if only an efficient scheme were arranged for utilising the different sources of supply.

It has been suggested that the distillation of water in some parts of the country might be useful and economical. The author has had some experience on this point, having lived for some years in a district in South America where all the water supply was obtained by the distillation of sea-water; and he does not recommend this system to be adopted where it can possibly be avoided.

It is proposed to divide England and Wales into the 12 districts shown on the maps accompanying this paper.

The river basins of England and Wales are generally classed under four divisions, viz.:—1. The North-West Division, comprising those rivers draining into the Irish Sea and St. George's Channel. 2. The South-West, draining into the Bristol Channel. 3. The Southern Division, draining into the English Channel; and 4. The Eastern, draining into the German Ocean. The lines of water-shed separating these divisions have been, in most cases, retained as boundaries between the proposed districts.

DISTRICT No. 1, OR THE NORTH-WEST DISTRICT.

This will be a large and a very important district. It includes the whole of the North-West of England, and is, in fact, almost identical with the North-West Drainage Division mentioned above; the boundary of the district agreeing with that of the division from the Cheviot hills to a little south of Bala Lake; it then turns northwards, and follows the western edge of the basins of the Dee and the Elwy, includes the Dulas, and reaches the sea at Colwyn. There are great difficulties in the way of diminishing the size of this district. It may now be considered as decided that the waters of the lake region of Cumberland and Westmoreland will be used for the supply of Manchester and other Lancashire towns, and, therefore, the district must extend from the Lakes to Manchester. It must then include the whole of the Mersey basin, otherwise part of this basin would be under one set of Commissioners and part under another, which would be most undesirable. Then, again, there is great probability that

Bala Lake will be utilised for the supply of Chester and Liverpool, so this must be included in this district. The lakes Ulleswater and Haweswater drain northwards into the Eden, thus extending the district nearly to the extreme north of England. As it is considered, in this scheme, desirable to include the whole area and population of England and Wales, in the 12 districts, the northern boundary of No. 1 has been drawn along the dividing line between England and Scotland, and therefore includes a portion of the basin of the Esk; but, in carrying out the scheme, it would probably be found advisable to omit this, and to stop the district at the northern boundary of the Eden basin. The area of this district is 6,613 square miles. It includes the whole, or nearly the whole, of Cumberland, Westmoreland, Lancashire, Cheshire, Flint, and Denbigh, and portions of Yorkshire, Derbyshire, Merioneth, &c. The population, in 1871, was 3,963,302, and the estimated population now is 4,446,157. It may be as well to mention here that the "estimated population now" has been in all cases obtained by taking the population in 1871, and adding to it the increase since 1861, thus assuming that the increase in the last eight years has been equal to that in the preceding ten. This method, perhaps, gives rather less than the actual increase, but is accurate enough as an approximation.

The principal river basins in the district are the Eden, draining Ulleswater and Haweswater; the Derwent, draining Derwentwater and Thirlmere; the Leven, draining Windermere; the Kent, the Lune, the Ribble, the Mersey, the Dee, and the Elwy. The strata in this district belong to the primary and to the lowest part of the secondary formations, the most recent being the Trias. The Lake region of Cumberland and Westmorland consists of the Cambrian or Silurian formations, which again occur round Bala Lake. The mountain limestone and millstone grit of the carboniferous series border the Silurian of Cumberland on the north and east, and form the ridge of the Pennine chain of hills which extend northwards from the High Peak of Derbyshire. They again appear to the south of the estuary of the Dee. The coal measures occur at Workington and Whitehaven, and in the district north of Manchester and Liverpool, and again are slightly developed south of the Dee estuary. The Permian strata are found near Whitehaven, and along a narrow strip of country from Allonby on the coast to Penrith and Brough; they also fringe the west and south sides of the coal-fields of Lancashire, and the east of those of Flintshire. The Trias, or New Red Sandstone, is largely developed; it forms the greater part of the basins of the Eden, the Mersey, and the Dee, and also occurs on the south-west coast of Cumberland, the west of Lancashire, and in the small basin of the Clwydd in the north-east of Wales. In the west and north of the district, however, this formation is extensively covered by alluvium.

The rainfall of the Lake district is very large, as much as 225 inches having been registered in one year at the Styc. Mr. Symons has given the true mean of the Lake district as 77 inches, that of three consecutive dry years as 61·6, and of the driest year as 53 inches. On Mr. Symons' map, in the Sixth Report of the Rivers Pollution Commissioners, a rainfall of over 75 inches per annum is given for the Lake district, and for the region from which Bala Lake is fed. The area, coloured as having a fall of between 50 and 75 inches, borders the Lake region, includes the head waters of the Eden, the Lune, and the Ribble, and extends along the eastern edge of the district as far south as Settle. There is a similar area in Wales, including Bala Lake, and reaching to Llanrwst. The next zone, 40 to 50 inches, extends from Silloth and Wigton to the north-east corner of Westmoreland; in Lancashire it includes Lancaster, Blackburn, Bolton, Rochdale, and Burnley. It also borders the last preceding zone in Wales. Almost the whole of the remainder of the district has between 30 and 40 inches of rain, a portion of Flintshire and the West of Cheshire having less than 30.

The percolation in the Permian and New Red Sandstone areas is large. The metamorphic rocks of the Cumberland and Westmoreland mountains rise to a considerable elevation near the coast, and the district is, on the whole, a very mountainous one, and most of the rivers rise on very high ground. In the northern and south-western parts of the district, where the older strata occur, the rain falling would be carried at once to the sea, were it not for the presence of the lakes, which act as regulators. Those rivers, which are fed from the Trias, are much more regular in their flow.

The rivers are for the most part largely polluted either by sewage or by trade refuse, the only exceptions being some small ones near the coast.

Although the population of this district is large, the available water supply is proportionally great, consisting both of upland surface water and of underground water from the Trias. The upland surface waters from the upper tributaries of the Mersey and the Ribble, on the millstone grit and mountain limestone, and from other rivers, have already been utilised, and more than 50 million gallons per day are now drawn from these sources, but there is still a vast reserve, in the Lake region, of excellent water, eminently suitable for manufacturing towns on account of its softness. The loss of water by evaporation throughout England and Wales varies from 9 to 20 inches per annum, and in mountain districts is generally taken at 14 inches. The compensation water given to the rivers, when their head waters are impounded, is usually one-third or one-fourth of the amount that can be collected. The area of the lake district is given by Professor Ansted as "nearly 800 square miles." Taking the rainfall of the driest year at 53 inches, deducting 14 inches for evaporation, and taking away one-third for compensation, there is left 26 inches, which would give rather more than one million gallons per square mile per day, or a total, taking the area at 700 square miles, of 700 millions gallons per day; enough to supply 28 millions people, whereas the population of No. 1 District is under 5 millions. The net produce of three or four dry years at the present gathering ground for Manchester, averages 33 inches. Messrs. Hemans and Hassard proposed to supply London by collecting the water from 177 square miles of the Lake district, including only the drainage areas of Ulleswater, Haweswater, and Thirlmere: they estimated the rainfall at 64, the loss at 14, and the compensation at 9 inches, leaving 41 inches, which would produce 287 million gallons per day. They also mention a

reserve area of 53 square miles to the east of Ambleside.

The area proposed to be utilised for the Thirlmere scheme is about 17 square miles. Mr. Bateman calculates the mean rainfall at 80 inches, and the loss at 8, leaving 72 inches, which gives about 50 million gallons per day.

Bala Lake has a drainage area of 56 square miles, and it is estimated by Mr. Hassard that 70 million gallons per day could be obtained from it.

The underground water of the Trias has already been extensively drawn upon, especially at Liverpool, where, however, it has not proved adequate to meet the demand upon it; owing, no doubt, to the proximity of the sea, and to the presence of faults in the strata.

Some controlling authority is greatly needed in this district, to regulate the supply to the different towns. The gathering grounds of Lancashire might be developed to their fullest capacity, any deficiency in the supply to the manufacturing districts being then made up from the more distant sources. The 70 million gallons per day which could be obtained from the Bala Lake drainage area would amply suffice for the South-Western part of the district, including Liverpool, and the Rivington district could then be given up to the towns in its neighbourhood, as recommended by Mr. Bateman in his evidence before the Commission on Water Supply. The south-eastern part of the district, situated as it is on the New Red Sandstone, might be supplied from that formation.

District No. 2, or the Welsh District.

This includes the remaining portion of the North-West River System, and that part of the South-West Division which is west of the Wye basin. The extreme south-west corner of the Wye basin, between Chepstow and Newport, as shown on the Catchment Basins Map of the Ordnance Survey Department, has been added to this district, as it does not drain into the Wye. The Wye has not been included in this district, because it is considered that the large body of water which could be obtained from its drainage area could be more usefully employed, and is more required in the Midland counties of England than in the South of Wales. The area of the district is 5,359 square miles, and it contains the whole of Anglesey, Carnarvon, Pembroke, Carmarthen, and Glamorgan, and the greater part of Merioneth, Cardigan, Brecknock, and Monmouthshire. The population, in 1871, was 1,089,926, and the estimated population now is 1,205,021. The principal river basins are the Conway, Glaslyn, Mawddach, Dovey, Teifi, Towy, Tawe, Neath, Taff, Rumney, and Usk. With the exception of a small area in the extreme south of Glamorgan, the strata in this district are entirely of the Palæozoic age, and principally belong to the Cambrian and Silurian, intermixed with trappean rocks. The Devonian or its equivalent occupies the greater part of the portions of Brecknockshire and Monmouthshire included in this district, and the carboniferous, principally consisting of the coal measures, covers a large area in Glamorganshire and Monmouthshire. These two formations also occur in the south of Pembrokeshire. On Mr. Symons' map it is shown that over 75 inches of rain falls on a strip of country extending from Snowdon to Cader Idris, and also on a small area on the borders of the district at Plynlimmon. From 50 to 75 inches falls on the greater part of the district. From 40 to 50 inches falls on the whole of Anglesea, except the centre; on the north coast and western promontory of Carnarvonshire; on the west of Merioneth and Cardigan, on the whole of Pembroke, the south of Carmarthen, the north and east of Glamorgan, and on the east of the preceding zone from Brecon to Cardiff. Less than 40 inches falls on the South coast, from Kidwelly to Llandaff, and in the basin of the Usk below Brecon, while a very small area east of Newport has a less fall than 30 inches.

The greater part of this district is more than 500 feet above sea, and it is separated from districts 1 and 3 by high mountains. In this district, as in No. 1, the rainfall is large and is carried rapidly off the land, but there are numerous small lakes which serve as regulators. A map issued by the Rivers Pollution Commissioners, in their sixth Report, shows that the rivers of this district are unusually free from pollution, the exceptions being those in the centre and those in the south-east. The southern part of the district is important, owing to its coal and iron industries.

The system most applicable to this Welsh district will probably prove to be that of storing the mountain waters. The streams on the west coast of Wales are described as being exceptionally pure, soft, and pleasant, and as the rainfall is considerably above the average, no difficulty will be found in providing an ample water supply throughout the district.

District No. 3, or the Severn District.

This is the largest of the 12 districts. It consists of the basins of the Severn, the Wye, the Bristol Avon, and the Yeo. The boundary on the east is the same as that between the south-west and the eastern river systems. On the south-west the Mendip Hills form the natural boundary of the Severn system. The area is 7,053 square miles. It includes the whole of Radnor and Hereford; nearly the whole of Montgomery, Shropshire, Worcester, Warwick, and Gloucester, and parts of Brecknock, Monmouth, Somerset, and Wiltshire, &c.

The population in 1871 was 1,763,363, and the estimated population now 1,856,754. On the west side of the district, the strata are of the primary age, Silurian in the Welsh counties, and Devonian in Monmouthshire, Herefordshire, and the south of Shropshire. The carboniferous rocks occur in isolated patches near Shrewsbury, in the Valley of the Severn, north and south of Bridgenorth, in the Forest of Dean, around Bristol, and in the Mendip Hills. The Permian is slightly developed east of the patches of carboniferous strata in Shropshire, and also round Coventry. The Trias occupies the remaining portion of the district to the north-east; the Warwickshire Avon and the lower part of the Severn form approximately its eastern boundary. The Lias appears east of this line, and extends north of the Avon at Pershore. The lower and middle Oolites occur in the south-west corner of the district, in the upper part of the basin of the Bristol Avon; and the upper Oolite and greensand are at the

extreme south-west, near Devizes. The rainfall is less than in the preceding districts. At the sources of the Severn it is over 75 inches. Then follows a narrow band on the western edge of the upper basins of the Severn and Wye, where it is between 50 and 75 inches. Then another narrow strip, extending to Llanfair, Newtown, and Brecon, where it is between 40 and 50. The next zone, that between 30 and 40 inches, is wider than the former ones, and extends a little east of the Welsh border, and there is a detached area of this zone round Cheltenham, Stroud, and Bristol. The rest of the district has between 25 and 30 inches of rain per annum. The western border of the district is very mountainous, and in the East and South are the Malvern, the Cotteswold, and the Mendip Hills. The centre and north are of lower but still of considerable elevation. In the upper basin the water of the Severn is soft, and free from mineral solids, but the eastern tributaries convey harder water from the triassic districts, and a large part of the main stream itself runs over the trias. This district would not be a difficult one to deal with, as the head waters of the Severn and the Wye would, if necessary, furnish an ample supply for the whole of it.

Mr. Bateman, in his scheme for supplying London from the sources of the Severn, proposed to collect the water from 204 square miles, and also pointed out a reserve area of 109 square miles in the basin of the Severn, and 60 in that of the Wye. He took 36 inches as the rainfall that he should be able to collect; which, after deducting one-fourth for compensation, would give about 220 million gallons per day; but he estimated the available quantity from the whole area at 300 million gallons. This would be enough for 12 million people.

Mr. Hamilton Fulton, again, estimated that there could be obtained from 440 square miles, in the catchment area of the Wye, after giving one-fourth for compensation, 393 million gallons per day. The proposed aqueducts in both these schemes keep in this district as far as the south-east corner of Warwickshire. In addition to the large body of water thus shown to be available in the west, a considerable supply could be obtained from the Triassic strata in the north and east, and from the Oolitic in the south-east.

District No. 4, or the South-West District.

This is composed of the remaining part of the south-west river system, and of part of the southern system. The division between these two systems extends in a very irregular manner, through Devon and Cornwall, and would make a very inconvenient boundary between different districts. It is proposed that this division should be followed from the south point of the basin of the Bristol Avon to near Crewkerne, and that the boundary should then be drawn down to the sea, between Lyme Regis and Bridport, so as to include the basins of the Axe and the Char. The Mendip Hills form the north-east boundary. The area of the district is 5,103 square miles. It contains the whole of Devon and Cornwall, and the greater part of Somersetshire. The population, in 1871, was 1,253,928, and the estimated population now is 1,264,767. The principal river basins are the Parret, the Taw, the Torridge, the Tamar, the Dart, the Teign, the Ex, and the Axe.

Palæozoic rocks form the greater part of the district. The Devonian system extends over most of Cornwall, and is largely developed in the north and south of Devonshire. The lower carboniferous strata occupy the centre and west of Devonshire. The Trias is represented by a strip stretching from north to south across Somerset and Devon, and including Bridgwater, Taunton, Exeter, and Sidmouth. The Lias is found in the centre and north of Somersetshire, and extends to the Channel at Lyme Regis. The lower Oolite forms the high ground on the eastern boundary of the district, while an outlier of the cretaceous system occurs in the south-east corner of Devonshire, in the basins of the Axe and Otter. Granite and metamorphic rocks form elevated areas at Dartmoor and in several parts of Cornwall. The rainfall exceeds 75 inches at Dartmoor. It is between 50 and 75 inches on the outskirts of the moor, and on the granite hills between Launceston and Bodmin. Almost the whole of the remaining part of Cornwall and the west of Devonshire has from 40 to 50 inches, and this extends eastwards to Barnstaple and Plymouth, and the east side of Dartmoor. The neighbourhood of Falmouth has rather less than 40 inches, and the fall is between 40 and 50 inches in the east of Devonshire, and the west and south of Somerset, and also in the north-east of Somerset at Wells and Glastonbury. The remaining portion of Somerset has less than 30 inches. The elevation of the greater part of this district is considerable, rising to about 1,800 feet in Dartmoor. Most of the river basins are shown as unpolluted on the map of the Rivers Pollution Commissioners. In this, as in the preceding districts, there is a large quantity of upland water available, owing to the heavy rainfall, and to the geological formations represented being principally of the palæozoic age, and therefore of an impermeable character. There are numerous streams of pure water rising in Dartmoor, and the elevated regions of Cornwall and the north of Devonshire would give large supplies. The more permeable rocks at the east of the district furnish underground waters.

District No. 5, or the Southern District.

This contains another portion of the southern drainage division, namely, that extending from the last district to the eastern side of the basin of the Titchfield, and including the Isle of Wight. The North Downs form the north-east boundary. The area is 2,798 square miles. The district includes the greater part of Dorsetshire and Hampshire, and about one-half of Wiltshire. The population in 1871 was 593,175, and the estimated population now is 637,638. The chief river basins are the Frome, Stour, Avon, Test or Anton, Itchin, and Titchfield. The oldest formation represented in this district is the lower oolite which forms the high ground at the south-west boundary of the district, and extends along the coast to Weymouth. This is succeeded by the middle and upper Oolites in the south-west of Wiltshire and north of Dorset, and at Weymouth and Portland. The greensand forms a narrow band towards the western side of the district, and in the Isle of Wight; while the chalk is largely developed, extending from Purbeck to Dorchester, and thence through the centre of Dorsetshire, forming the whole of the district

north of Salisbury and Winchester. It also forms the centre ridge of the Isle of Wight, and underlies the tertiary strata which cover the east of Dorsetshire, the south of Hampshire, and the north of the Isle of Wight. The rainfall of this district is only moderate in quantity. The highest zone is that between 30 and 40 inches; this covers the southern part of the district, and includes Shaftesbury, Salisbury, and Winchester. The rest of the district has between 25 and 30 inches per annum. This district is of less elevation than the preceding ones, but it is bounded on the west by the oolitic hills, separating it from No. 4, and on the north by the chalk hills forming Salisbury Plain and the commencement of the North Downs.

The map before referred to shows that in the whole of Dorsetshire, in nearly the whole of Wiltshire, in the south of Hampshire, and in the Isle of Wight the river basins are unpolluted. As there is a large area occupied by permeable strata, more especially by the chalk, large quantities of underground water could be obtained in this district. Water is also now collected from the surface of the lower tertiaries; this is described by the Rivers Pollution Commissioners as probably not unwholesome. In some parts of the tertiary area the supply is at present unsatisfactory; but there would be no difficulty in providing good water for all the wants of the district from within the district itself.

District No. 6, or the South-east District.

This is made up of the remaining portion of the Southern river system, and the basins of the Medway and the Stour. The reason for including these two basins is that their interests, as regards water supply, are in no way bound up with those of the Thames basin, and the latter will form by itself a district so large and populous that it is advisable to limit it wherever possible. The division between districts No. 5 and 6 is an arbitrary one, and there would be no difficulty in uniting them if it were thought desirable; but considering that when so united they would form a very long district—longer, in fact, than any of the others, and that there is no reason, connected with their geological formations, or with the sources of water supply available in each district, why they should not be separated, it has seemed to the author preferable to form them into two distinct districts. They will not be by any means unimportant. There are numerous health resorts seattered along the coast, at which it is most essential that there should be a good supply of pure water. The area of this district is 3,057 square miles, comprising the whole of Sussex, the greater part of Kent, and part of Hampshire and Surrey. The population in 1871 was 1,094,186; the estimated population now is 1,225,214. The river basins are the Portsmouth, Arun, Adur, Ouse, Rother, Medway, Stour, &c.

There is no geological formation here older than the Wealden, which occupies the centre of the district in the Weald of Kent and Sussex; it extends to the northern boundary of the district, but on the west, the south, and the north-east it is surrounded by a narrow strip of the greensand strata, while the chalk stretches from Brighton and Beachy Head towards Winchester, forming the South Downs, and enters the district again at Rochester, extending to Dover and Deal, and forming the eastern spur of the North Downs. The tertiary clay forms a narrow strip along the coast from Brighton to Fareham, and again north of Rochester and Canterbury. The rainfall is about the same as in No. 5. It is between 30 and 40 inches over the central part, and between 25 and 30 over a narrow area along the south coact, including Havant, Chichester, Lewes, and Battle, and over a wider one on the north and east, reaching from Chatham, Canterbury, and Sandwich, nearly to Tunbridge Wells and Ashford. The extreme north of Kent, including the Isles of Sheppey and Thanet, has less than 25 inches.

The centre of the district is of moderate elevation; it rises to about 640 feet. The rivers are for the most part short and unimportant. Their basins, with the exceptions of the Medway and a small area round Canterbury, are unpolluted. The country covered by the Wealden strata is not very abundantly supplied with water; but, as the population is not great, there will probably prove to be a sufficient supply in the springs and wells. Although the water from this formation is inferior, both in quality and quantity, to that from that from the New R d Sandstone, the Oolite, and the chalk, it is yet good and wholesome, and sometimes soft. Tunbridge Wells is supplied from a spring in the Wealden, and Hastings from an artesian well. In that part of the district where the chalk and greensands occur, an ample supply of good water could be obtained, and in many places has already been. The chalk springs near Havant are so abundant that it was even proposed by Mr. Ewens, before the Royal Commission on Water Supply, to utilise them for the supply of London. They can, however, be more profitably used in the populous district in their neighbourhood.

District No. 7, or the Thames District.

This is conterminous with the catchment area of the River Thames, excluding the Medway. Although of less area than some of the other districts, it contains the greatest number of inhabitants. If, as is proposed, the future supply of London be obtained within the catchment area of the Thames, it seems impossible to separate the interests of the metropolitan district from those of the other towns and villages in that area and the whole basin should, therefore, be placed under one authority as regards its water supply—which authority should also have complete control over the River Thames itself and its tributaries.

The area of the district is 5,172 square miles. It includes the whole, or nearly the whole, of Oxfordshire, Berkshire, Hertfordshire, Middlesex, and Surrey, with large portions of Buckinghamshire, Gloucestershire, Wiltshire, Hampshire, Kent, and Essex.

Its population in 1871 was 5,040,096, and its estimated population now is 5,804,351. The lias is the most ancient of the geological formations in this district; it is found only at the extreme north-west. The lower Oolitic strata of the Cotteswolds are of great importance, for on these rise many of the most important of the earlier feeders of the Thames. The middle and upper Oolites follow in narrow bands. The Wealden in the south part of the district gives rise to the Mole. The greensand stretches from between Aylesbury and Tring,

southwards, through Wantage, towards Devizes, and also occurs in Surrey, south of the North Downs. The chalk is of greater extent, and reaches from the greensand on the west to Bishop's Stortford, Hertford, Watford, Reading, and Hungerford; it then forms the crest of the North Downs, and the lower part of the valley of the Darent.

The remainder of the district consists of the tertiaries overlying the chalk. Of these the London clay covers the largest area, but there is a considerable extent of country, about 200 square miles, round Bagshot covered by the permeable Bagshot sands. The rainfall is nowhere very great. The average of the upper basin is about 30 inches, and that of the whole basin is 26 or 28 inches per annum. The highest zone on Mr. Symons' map is that between 30 and 40 inches, covering a small region at the head of the Thames, Churn, and Coln, and another at the head of the Wey and Mole. The next zone, 25 to 30, extends eastwards as far as Oxford, and nearly to Reading, and takes in all south of a line drawn from just below Reading to Croydon, and to below Gravesend. There is also an isolated portion of this zone round Tring, St. Albans, and Luton. The rest of the district has a fall of less than 25 inches. There are several ranges of hills of considerable elevation in the west and south; namely, the Cotteswolds, the Chilterns, and the North Downs. The water-shed between the Thames and the Severn is at the highest over 800 feet, but mostly below 400 feet. That between the Thames and Ouse is generally not more than 300 feet. The flow of the rivers is large in comparison with their drainage areas. They are all shown as polluted on the map of the Rivers Pollution Commissioners, but they do not of course become polluted for some little distance below their sources. The mean evaporation throughout the basin is usually assumed at 15 inches, but Mr. Greaves considers that near London it is 18 inches, or 72 per cent. of a rainfall of 25 inches. There is a large percolation over most of the district, and Mr. Bravender estimates the mean amount of rainfall available in the upper part of the basin at between 9 and 11 inches. The amount of percolation through the chalk, estimated by different authorities, varies from 4 to 18 inches per annum.

The evidence taken by the Commissioners on Water Supply, and on Rivers Pollution, proves conclusively that there is an ample supply of water in this district for all its inhabitants. On the west, abundant streams of excellent water are poured forth from the oolitic rocks, while in the centre and the east, the chalk furnishes a large supply, not only at the outcrop, but even where it passes under the tertiaries.

The Royal Commissioners on River Pollution say, in their 6th report:—"We have found no catchment basin so rich in springs of the finest drinking water as that of the Thames. The chalk, Oolite, and greensand make up a very large proportion of the collecting ground of the Thames basin, and even where they dip below the London clay, or the other impermeable formations, are easily accessible to the boring rod. We are of opinion that the whole of the metropolis and its suburbs should be supplied exclusively with the spring and deep well water of the Thames basin." They further state that, within 40 miles of St. Paul's, a sufficient volume of deep well and spring water can be obtained for the present daily wants of the metropolis, and they estimate that, taking only 6 inches of the rain-fall, 512 million gallons per day could be obtained within 50 miles.

Mr. Bailey Denton, in his evidence before the Commission on Water Supply, estimated that 100 million gallons per day could be obtained from the upper sources of the Thames, 60 million gallons from the Lea, and 40 million gallons from the Wey and Mole, making a total of 200 million gallons exclusive of the Colne and the Wandle.

Mr. Hawkesley considered that half of the lowest volume of the Thames, which he calculated at 360 million gallons per day, might be taken without any storing process. Mr. Simpson thought the Thames capable of supplying 200 million gallons per day, and the Lea 60 million. Mr. Beardmore said that with storage reservoirs 300 million gallons could be obtained from the Thames and Lea. Mr. Leach, engineer to the Thames Conservancy, said there was a district above Oxford well calculated for the formation of reservoirs, and thought that, with storage reservoirs, 200 million gallons per day might be taken. The Commissioners summed up the evidence by estimating that 220 million gallons could be obtained from the basin of the main stream, 50 million from that of the Lea, and 50 million from the chalk, making a total of 300 million gallons per day. The present supply to London is about 120 million gallons a day. If, however, we take the population of the whole water-shed at six millions, this multiplied by 25 gallons, will give 150 million gallons per day; just half the quantity estimated to be available in the water-shed. The estimate of 30 million gallons obtainable from the chalk is an exceedingly moderate one, and the quantity now drawn daily from this formation in the whole water-shed is probably nearly, if not quite, as much as 30 million gallons. Large quantities are obtained from wells in London itself. The Kent Water-works Company pump from their wells on the outskirts of the Metropolis enough, it is said, to supply the whole of London with sufficient water for drinking and cooking. At Grays, in Essex, as much as 7 million gallons per day has been raised, and the district in the neighbourhood is now supplied from this source.

From the chalk wells of the Tring and the Caterham Water-works Companies, and of the New River Company, several million gallons a-day are obtained. It would extend this paper to too great a length to go fully into the evidence that has been given, from time to time, as to the area of the different formations in the Thames basin; as to the extent to which they may be depended on to furnish water; and as to the actual flow of the Thames and its tributaries. The reports of the Royal Commissioners go very fully into these questions, and they have been frequently discussed since those reports were issued. The author will only, therefore, sum up by expressing his conviction that it will be quite unnecessary to go beyond the basin of the Thames for the supply of the population of that basin, within any time that we need at present look forward to. He does not feel called upon to say anything as to the mode in which the present supply should be improved, but will repeat

what has been stated in a former part of this paper, that no scheme can be considered satisfactory which does not take into account the large amount of capital already expended on water-works.

DISTRICT No. 8, OR THE EASTERN COUNTIES DISTRICT.

Several different ways of dividing the country between the Thames and the Humber might be suggested, each having its advantages. The basins of the Great Ouse, Nene, Welland, Witham, and Trent are connected by artificial cuts or canals, so that it is impossible to create districts which shall be entirely independent of each other. Much might be said in favour of uniting together the four large rivers that drain into the Wash; namely, the Ouse, the Nene, the Welland, and the Witham; but this would leave two small and inconvenient districts, one on the coast of Lincoln, and the other on the coasts of Norfolk, Suffolk, and Essex; or if these were included in the same district as the four large rivers, this district would be of great size. The author, after much consideration, has determined to separate the Ouse from the other Fen rivers, and to make this No. 8 district consist of the basin of the Great Ouse, and all the country to the east of it. That portion of the basin of the Ouse, however, which is in the Middle Level, has been placed in the next district, so that the whole of the Middle Level might be in the same district as the Nene, from which it usually draws its water supply.

The area of District No. 8 is 6,394 square miles. Its population in 1871 was 1,437,804, and its estimated population now is 1,483,329. It contains the whole of Suffolk, nearly the whole of Bedfordshire, Cambridgeshire, and Norfolk; and parts of Northampton, Buckinghamshire, Huntingdon, Essex, &c. The principal river basins are the Great Ouse, Yare, Waveney, Orwell, Stour, Colne, and Blackwater. The Lias occurs only in the extreme west, in Northamptonshire. The lower Oolite follows and extends to Buckingham and Bedford. The middle and upper Oolites succeed, widening out in Huntingdonshire, where there is a considerable area covered by the Oxford clay. The greensand stretches from the south-west of Bedfordshire to Ely, its eastern boundary passing near Dunstable and Cambridge. It also forms the eastern border of the Valley of the Ouse, from a little below Ely to Hunstanton. The chalk forms a zone of considerable breadth, including the east of Cambridgeshire, the west of Suffolk, and the greater part of Norfolk. The eastern portion of this area is, however, largely covered by newer deposits. On the eastern and south-eastern borders of this district are the tertiaries, belonging for the most part to the upper division, overlying the chalk.

The rainfall of the whole district, with the exception, perhaps, of Leighton Buzzard, is less than 25 inches per annum.

The northern and eastern parts of the district are low, but in Northamptonshire, and in the south of Bedfordshire, there are hills of considerable elevation, and there are the Gog Magog hills and the East Anglian hills in Cambridgeshire and Norfolk respectively. The Great Ouse brings down large volumes of water in winter and spring, generally causing extensive floods, but in summer its flow is comparatively small. Its sources are in the lower Oolites, at an elevation of nearly 300 feet. The river basins are polluted, except in Essex, in the east of Suffolk, and in the north of Norfolk. The centre and east of this district have the greensand and the chalk as their sources of water supply, while the extreme west has the lower Oolite. The region most difficult to deal with will be that covered by the Oxford clay. This stratum is of great thickness, and contains very little water. Huntingdon, which is situated on this formation, has obtained a good supply from a gravel hill, to the west of the town.

DISTRICT No. 9, OR THE LINCOLNSHIRE DISTRICT.

This is composed of the basins of the Nene, the Welland, the Witham, and the Ancholme, together with the small basins on the east coast of Lincolnshire, and with that part of the Middle Level which is in the basin of the Ouse. Its area is 3,952 square miles, and it includes nearly the whole of Lincolnshire, Rutlandshire, and Northamptonshire, with part of Huntingdonshire, Cambridgeshire, Norfolk, &c. Its population, in 1871, was 740,836, and its estimated population now is 781,709. The lias forms the western boundary of the district; reaching to Northampton, Oakham, and Lincoln. The lower Oolite is found along the valley of the Nene, from Northampton to Peterborough, and forms a band of considerable width through the centre of Lincolnshire, from the north to the south. The Oxford clay of the middle Oolite is not very extensively developed on the surface, but passes under and forms the basement of the greater part of the Fens, except in the south, where it is replaced by the Kimmeridge clay of the upper Oolite. The upper Oolite, greensand, and chalk succeed one another in the north-east of Lincolnshire, from the mouth of the Ancholme to Wainfleet. The chalk is covered near the coast by more recent deposits. The rainfall of this district ranges from 25 inches to 20 inches, or even less. Twenty-one or 22 inches is usually given as the rainfall of the Fens.

The south-eastern part of the district is flat, but in the west there are hills of moderate elevation, and in the north-east are the Lincolnshire Wolds. The Nene and Witham rise at an elevation of about 300 feet. The Fen rivers bring down floods in the wet seasons, but dwindle to comparative insignificance in the dry seasons. A great amount of labour and money has been expended on them during the last three centuries, but with only partially satisfactory results.

The eastern part of the district is not coloured as polluted on the map of the Rivers Pollution Commissioners, but the lower parts of the basins of the Witham and the Welland can scarcely be considered as being free from pollution.

The south-eastern portion of the district will prove a most difficult country to provide for; but that the difficulty is not insuperable is proved by the fact that the larger towns, such as Boston, Spalding, Peterborough, and Wisbeach, have succeeded in obtaining good supplies of water at a moderate expense.

In the north-eastern portion, the cretaceous strata may be relied on to furnish a supply. Mr. Shelford mentioned at the Congress last year that a large body of water finds its way from the chalk wolds of Lincolnshire to the German ocean. The

county of Northampton is remarkable for the number of springs proceeding from the lower Oolites, and in the south of Lincolnshire, in the district round Bourn, large volumes of water are given out by these strata in springs and wells. The Braceborough Spa, which is still not utilised, is said to give a million gallons per day.

The present supply to the villages in the Fenland is most unsatisfactory, many of them being supplied from polluted shallow wells in the surface gravel, and others from the rivers and drains. Much of the lower part of the Nene basin and of the Middle Level has no source of supply except the River Nene, below where the sewage of Peterborough is, or was until lately, poured into it. Unfortunately the lower Oolites which give such a liberal supply in the centre of the district thin out as they pass under the more recent strata in the east and south-east. Thus water cannot be obtained in the Fen-land by boring, but must be brought from a distance.

District No. 10, or the Midland District.

This is formed by the basins of the Trent, the Derwent, and the Don. It is bounded on the West and South by the line of water-shed separating the River System of the East of England from the North-West and South-West Systems. There will be no great difficulty in separating the Don from the more northerly part of the Humber basin, and placing it under the same jurisdiction as the Trent. This jurisdiction will extend to the out-falls of these rivers into the Ouse.

The area of this district is 4,732 square miles. It takes in nearly the whole of Derbyshire, Staffordshire, Leicestershire, and Nottinghamshire, and part of Yorkshire, Lincolnshire, Warwick, &c. Its population in 1871 was 2,746,190, and its estimated population now is 3,133,837. The carboniferous formation forms the north-west of the district, and occurs in detached portions in the South. In South Staffordshire and South Yorkshire are coal fields, while the mill-stone grit and mountain limestone cover a wide band of country in the north-west, in which are the sources of the Dove, the Derwent, and the Don. The Permian adjoins the patches of carboniferous in the south, and forms a border on the east to the South Yorkshire coal-field, extending east to Nottingham and Doncaster. The magnesian limestone in the valley of the Don has a considerable thickness. The Trias occupies nearly the whole of the remainder of this district, leaving a narrow strip on the eastern border which is covered by the Lias.

The maximum zone of rain is that between 30 inches and 40 inches. This occupies the north-west corner, and extends to Sheffield, and includes the west of Derbyshire, and the north and centre of Staffordshire. The next one, 25 to 30 inches, forms a narrow strip in the south-east of Yorkshire, covers the south of the district, and extends east as far as Leicester, Mansfield, and Rotherham. The rest of the district has less than 25 inches. In the Peak district of Derbyshire, and at the head waters of the Don, the hills are of considerable elevation, but in the north-east of the basins of the Don and Trent are large tracts of low-lying land covered with alluvium. The Trent and Don are subject to floods, and generally have a considerable flow. Their waters are polluted.

There is abundance of water in this district. The head waters of the Don are already largely drawn upon for Sheffield and other towns, but in the north of Derbyshire are gathering grounds not hitherto utilised. Mr. Easton, in his evidence last year on the Thirlmere scheme, said that there are 20,000 acres available at the head waters of the Derwent and its tributaries, 800 feet above the sea, besides smaller areas, sufficient to provide the compensation water, and he estimated the total available quantity from the 20,000 acres at 50 million gallons per day.

The Commissioners on Water Supply mention a scheme of Mr. Remington for bringing water from the hills of Derbyshire to London; collecting it at a point above Mill Dale on the Dove. The area proposed to be utilised was 262 square miles. The rainfall was taken at 48 inches, and Mr. Remington expected to be able to collect one-sixth of this, giving 83 million gallons per day.

In addition to these upland waters, there exists a large reservoir of water in the trias. The area of the Trias in the basin of the Trent is given by Professor Ansted as 2,500 square miles, but over a large part of this area the Trias is covered by drift or alluvial gravel. The South Staffordshire Waterworks and the Staffordshire Potteries Waterworks draw large supplies from these strata, and many of the towns situated on this formation are supplied with water from it—such are Birmingham, Leicester, Nottingham, &c. In Leicestershire, where the Bunter and Permian beds are penetrated, the supply is enormous, and entirely unaffected by dry seasons, and it is pure and perfectly soft. (See First Report of the Committee on Underground Waters, appointed by the British Association).

District No. 11, or the Yorkshire District.

This is bounded on the north by the basin of the Tees, and on the west by the Pennine Chain. Its area is 4,682 square miles, and it includes the greater part of Yorkshire. Its population in 1871 was 1,871,933, and its estimated population now is 2,167,202. It contains the basin of the Ouse, with those tributaries above the Don. It also contains the basins of the Hull, &c., on the north of the Humber, and those of the Esk, and some other small rivers in the north-east of Yorkshire, which it is considered should belong to this district rather than to the succeeding one. The lower carboniferous forms the western part of the district, and a small area of coal measures occurs in the south. The Permian forms a strip across the centre, thinning out towards the north. The Trias occupies a considerable area along the valley of the Ouse, from Richmond to the outfall into the Humber, and also forms the valleys of the lower part of the Derwent and of the Aire. A band of Lias borders on the north and west, the Oolite hills of the north-east of Yorkshire. The chalk wolds in the south-east of the district are fringed on the west by the greensand and the Kimmeridge clay. East of the River Hull the chalk is covered by recent deposits. A large area of the Trias is thickly covered with alluvium and boulder clay. The rainfall in the extreme west is between 40 and 50 inches. The zone of 30 to 40 inches includes Huddersfield, Bradford, and Richmond. That of 25 to 30 inches extends to Wakefield,

Knaresbourgh, and Northallerton, and there is an isolated area on the hills in the east. The rest of the district has less than 25 inches. The western and north-eastern portions of the district are very elevated, the south-eastern being of less elevation. The eastern part of Yorkshire, including the basin of the Derwent, is unpolluted. The western side of this district is well suited for the collection of upland waters. The Commissioners on Water Supply say that the Yorkshire manufacturing towns can be well supplied from districts near to them. These districts already furnish large quantities of water. At Leeds, Bradford, and Halifax the supply to the suburbs and the towns is nearly 20 million gallons a day.

The oolitic strata in the north-east, and the chalk in the south-east supply the eastern side of the district. Mr. Mortimer, in a paper published in the 55th volume of the Proceedings of the Institution of the Civil Engineers, says, that the area of the out-crop of the chalk of Yorkshire is about 420 square miles, with an average rainfall of 27 inches, and that the extent of sub-aerial water-containing chalk is 780 square miles, whose average depth may be taken at 350 feet. The minimum water line in the country to the east of the out-crop is in no case more than 300 feet deep.

District No. 12, or the North-Eastern District.

This is the last district. It is bounded on the west by the mountainous water-shed separating the east and north-west river systems. The same difficulty occurs in this district as in No. 1; namely, that the northern boundaries of the river basins are not identical with the boundary between England and Scotland. In calculating the area and population of the district, this latter boundary has been taken as the northern limit. In drawing up a working scheme, it would probably be found convenient, either to include the whole of the basin of the Till, a tributary of the Tweed, which would necessitate the taking into the district of a small part of Roxburghshire, or else to exclude the catchment area of of the Tweed altogether. The area of the district is 3,405 square miles. It includes the whole or nearly the whole of Northumberland and Durham, and small portions of Cumberland and Yorkshire. Its population in 1871 was 1,109,369, and its estimated population now is 1,336,013.

The most important rivers are the Tyne, the Wear, and the Tees. The geological formation is almost entirely carboniferous, and chiefly the carboniferous limestone. There is a coal-field in Durham, and the south of Northumberland. The Permian occurs in the east of Durham, and the Trias in the extreme south-east, from Hartlepool to Darlington. There are trappean rocks in the Cheviot Hills, and they form the dykes which traverse the district.

The rainfall, according to Mr. Symons' map, does not exceed 50 inches. There is a fall of between 40 and 50 inches in the north-west, from Haltwhistle northwards. The 30 to 40 inches zone extends to about the middle of the district, and the 25 to 30 inches occupies all the remainder except to the east of Durham and Darlington, where it is less than 25 inches. This district is a mountainous one, the Pennine and Cheviot Hills rising to great elevations. The river basins, north of the Tyne, are unpolluted.

The water supply to many parts of this district is at present unsatisfactory, being drawn from rivers polluted by sewage. Some of the towns, however, have sought and obtained purer supplies. The permian in Durham yields unusually large supplies, and it is stated in the third report of the British Association Committee that 5 million gallons per day are pumped from an area of 50 square miles without altering the level of the water. This is used for the supply of Sunderland and the adjacent district. Other towns are supplied by springs from the mountain limestone; and others, again, as, for example, Newcastle—from upland gathering-grounds.

These districts would not be entirely independent of one another. Canals and drains, in many instances, take water from one district and convey it to another. Thus, the Foss Dyke goes from the Witham to the Trent, the Middle Level Drain from the Nene to the Ouse, &c. Some cases occur in which a town situated in one district obtains water from another; as, for example, Wolverhampton, Wisbech, and Dewsbury. These and other points could be easily arranged between the different bodies of Commissioners.

In conclusion, the author hopes that it will be remembered that this scheme is only put forward as a suggestion, not as a final or working scheme. Before any working scheme is drawn up, it will be necessary to have a thorough examination made of all the sources of water supply available in the country. Very little is known with certainty as to the amount of rainfall which can be collected in any district, either as upland water, or as subterranean water. Accurate information is also needed as to the existing water supply to every town and village in the kingdom, and as to the gathering grounds already utilised for the collection of upland surface water. Very few of the rivers have been regularly gauged, so that it is impossible to ascertain what proportion of the total rainfall reaches the rivers. All these points must be gone into before a satisfactory scheme for the water supply of England and Wales can be made.

Schedule of Proposed Districts.

Number.	Area Square Miles.	Estimated Population.
1	6,613	4,446,157
2	5,359	1,205,021
3	7,053	1,856,754
4	5,103	1,264,767
5	2,798	637,638
6	3,057	1,225,214
7	5,172	5,804,351
8	6,394	1,483,329
9	3,952	781,709
10	4,732	3,133,837
11	4,682	2,167,202
12	3,405	1,336,013
Total	58,320	25,341,992

Population in 1871, 22,704,108.

MISCELLANEOUS.

LIVERPOOL WATER SUPPLY.

The following correspondence between Mr. Alderman Bennett, of the Liverpool Water Committee, and Mr. Baldwin Latham, has been forwarded by Mr. Bennett to the *Journal*, with a request for its publication :—

Heysham Tower, Lancaster,
June 10, 1879.

MY DEAR SIR,—I see on page 619 of the *Journal of the Society of Arts*, for June 6th, 1879, you say "With regard to water from the Red Sandstone, he understood that the Corporation of Liverpool had abandoned the deep well for procuring additional water supply, because the deep boring, carried to a depth of 1,300 feet, was shown to yield no more water than the shallow boring, and they declined to go to any further expense." In reply to Mr. Homersham you say, "If he were wrong, he might be corrected, but that was the impression he got when he visited the works."

Will you kindly inform me from whom you obtained the above information? It is of importance to me that I should know, as I hear that similar untruthful observations have been made to other gentlemen.

Yours truly,
WM. BENNETT,
A member of the Liverpool Water Committee.

Baldwin Latham, Esq., C.E.

7, Westminster-chambers,
Victoria-street, Westminster, S.W.,
20th June, 1879.

DEAR SIR,—I have been unable to reply to your letter of the 10th inst. sooner, owing to absence from town.

My remarks at the Society of Arts Congress with reference to the abandonment of the deep well, only implied that I understood, from what I had read in the public press, the Corporation of Liverpool had determined not to prosecute any further experiments by boring for procuring water from under the town of Liverpool, but that they had under consideration the procuration of water from an entirely different source. My remarks, therefore, need amendment, to the effect that the Corporation of Liverpool had not determined to abandon the deep well already bored, but they did not contemplate any further extension for procuring additional supplies of water for Liverpool from the deep borings under the town. When I visited the works at Liverpool some time ago, I learnt from the man in charge of the boring apparatus that no experiments had been made to test the quantity of water yielded by the boring, from time to time, as it proceeded. My opinion was based upon such information as I had given to me, coupled with the fact that, judging from the increasing density of the strata passed into at the greater depths to which the well was bored, and the level of the water in the contiguous pumping well, the conclusion I had arrived at with reference to the yield of this bore was that expressed at the Society of Arts meeting. Having regard also to the fact that the movement of underground water diminishes greatly with increased depth, and obeys in its movements exactly the same laws as water flowing upon the surface, it follows that the deep bore will not give anything like the amount of water that increased diameter of the bore would give at even a shallower depth. In water-bearing strata, like that of Liverpool, in which water occupies the whole strata from top to bottom, very little movement of water takes place in the lower portions of the strata. The circumstances are very different in the case of a true artesian well, where the impermeable strata is passed through in order to tap the water-bearing strata. Such, I understand, are not the conditions at Liverpool. You will observe that I stated, in reply to Mr. Homersham, that if wrong, I should be glad to be corrected in the conclusion I had arrived at. I shall feel obliged if you will inform me if any experiments were made to show the quantity of water yielded by the well at Liverpool at the different depths at which it was sunk, and if so, will you give me the results, or publish them in the Society of Arts *Journal*, so as to set this matter at rest? I should also like to ask you, if, since the well has been completed, it has been plumbed, to ascertain if the bore-hole is of the same depth as originally bored, as I have found, in cases where little or no water is yielded by a deep bore in a similar geological formation, that the sediment from the upper part of the strata passes into the bore and slowly silts it up, and, where this is found to be the case, it is conclusive evidence that no water is procured from the great depths, as otherwise, if there were an upward current of water, this silting up would not take place.

I am, with you, a firm believer that abundant supplies of water may be procured from the New Red Sandstone and Permian beds in Lancashire, but I am strongly of opinion, having regard to the proper sanitary requirements of Liverpool, that the place for seeking water is not under the town, where the water is liable to contamination from sewers and other sources of pollution, but that the site for such wells should be carefully selected with regard to the physical features and possible sources of pollution in the neighbouring districts.

Yours faithfully,
BALDWIN LATHAM.

Mr. Alderman Bennett,
Liverpool.

109, Shaw-street, Liverpool,
June 23rd, 1879.

Re "Bootle Bore-hole."

DEAR SIR,—Your reply to my letter of the 10th inst. came to hand on the 21st inst. I much regret that so circumstantial a statement on the above was made by you from what you had read in the public press, in which I have seen nothing to warrant your conclusions; your remarks do indeed, as you say, "need amendment." You are equally in error in supposing that the Corporation do not contemplate "any further extension for procuring supplies of water for Liverpool from deep borings under the town."

You may be right in saying that you learnt "from the man in charge of the boring apparatus, that no experiments had been made to test the quantity of water yielded from time to time as it proceeded," but as machinery capable of raising from eight to ten million gallons of water per week would have been necessary for such experiments, they could not have been made without serious interference with the progress of the work.

Your ideas upon deep spring supply, as well as the ideas of some members of our Water Committee, want testing by such facts as I hope the Bootle bore-hole in a few weeks will supply. Your notions of "a true artesian well" I do not, in the least, wish to dispute. I am not aware of any system of accurately testing the yield during progress of such a bore-hole as that of Bootle, when the yield may be from 8 to 10 million gallons per week, so that I cannot give you the results you ask for.

Your next remark is such an important one that I copy it in full:—"I should also like to ask you if, since the well has been completed, it has been plumbed, to ascertain if the bore-hole is of the same depth as originally bored, as I have found, in cases where little or no water is yielded by a deep bore in a similar geological formation, that the sediment from the upper part of the strata passes into the bore and slowly silts it up,

and, where this is found to be the case, it is conclusive evidence that no water is procured from the great depths, as, otherwise, if there were an upper current of water, this silting up would not take place." I am happy to inform you that, "in a similar geological formation" (Bootle well, but a few feet distant, and Green-lane well, about two miles away), this has been fully tested, the deepest bore-hole at Bootle having been plugged up for six months at one time, and that at Green-lane for years, without producing a decrease of yield of more than, perhaps, a million gallons per week at the two. These risky experiments were made without my consent, and, I believe, without the knowledge of the committee.

You further say, "I am, with you, a firm believer that abundant supplies of water may be procured from the New Red Sandstone and Permian beds in Lancashire, but I am strongly of opinion, having regard to the proper sanitary requirements of Liverpool, that the place for seeking water is not under the town, where the water is liable to contamination from sewers and other sources of pollution, but that the site for such wells should be carefully selected with regard to the physical features and possible sources of pollution in the neighbouring districts."

As to quantity, I think you are quite correct, but, as regards situation, I entirely differ from you. Water flowing upwards to the extent of two or three million gallons a day, through a 2-foot bore-hole, cannot be supposed to be forced into position by the slow percolations of defective local sewers.

I would not hesitate to commence boring for pure water at any spot in one of the many acres of midden beds laid by our Health Committee for cottage erections, merely taking the simple precaution of effectually cutting off all risk of local contamination.

As your remarks were made public, and were made in ignorance of important facts, you will, I am sure, assist me in making these facts as public as possible.

Yours truly,

Wm. Bennett.

Baldwin Latham, Esq., C.E.,
Westminster, S.W.

7, Westminster-chambers,
Victoria-street, Westminster, S.W.,
26th June, 1879.

Dear Sir,—I have to acknowledge the receipt of your letter of the 23rd inst., in reply to my letter of the 20th.

Since first writing to you, I have found the notes which I made when making an inspection of the new bore at Liverpool, from which I find that the stratification of the strata at the great depths shows a considerable incline from north-west to south-east, being exactly in the direction in which the surface beds at Liverpool lie. I was further informed by Mr. John Harrup, who was the party who conducted me over the works, that the water in the new bore-hole stood at a level of about 52′ 6″ below the level of the surface of the ground, except that on Monday mornings it was 18″ higher, and that the water in the Bootle well adjoining was pumped down to a level of 100 feet below the surface. These conditions of the relative height of the water in the well and bore-hole indicate that they both tap the same underground stream, and, moreover, that the deep well was subject to all the fluctuations of the shallow wells in Liverpool, as it was influenced by the cessation of the pumping from the shallow wells on Sundays. You are quite aware that formerly the spring water used to overflow the surface at Bootle, but by constant pumping the great body of water under Liverpool has been exhausted, and it now no longer rises to the surface.

I presume you will admit that the whole of the strata at the site of the new bore-hole, from top to bottom, is of a permeable character, and that water is found in all parts of this strata from top to bottom. This being so, the rush of water up the bore-hole, of which you speak, as preventing any impurities from the surface entering the well, you will allow, must come from a higher source than water within the bore itself, or otherwise there could not be this upward current; and as the water stands in the bore-hole within 53 feet of the surface of the ground, the source of the water in the bore-hole must be located at least at as high a level, and, therefore, in all probability is within a short distance of the surface. I am quite aware that it is a common error, even amongst engineers, to suppose that the upper part of a well in a permeable strata may be lined with cylinders, or other means may be adopted to shut out the surface water, but no greater fallacy exists at the present day. It is utterly impossible, in a permeable strata, to shut out the upper water under the conditions under which the movement of subsoil water takes place in a permeable strata. This has been subjected to direct experiment in several places, and it is shown beyond all doubt that, where water occupies a pervious geological formation, it is but one water, and that the great movement of the body of underground water takes place at the surface of the underground stream. I think, therefore, although you state you "would not hesitate to commence boring for pure water at any spot in one of the many acres of midden beds" of Liverpool, that in course of time, when you become more conversant with the movements of underground water, you will, like myself, see the fallacy of ever having held such an opinion.

With reference to the experiments of which you speak as to the stopping up of the bore-holes in the well at Bootle and Green-lanes, and the small extent to which it affected the yield of the wells, this is one of the strongest pieces of evidence that could be given in support of my remarks at the Society of Arts Congress, as it appears that when the deep bores were stopped up the yield of water declined but to a small extent, showing, as I have already tried to explain, that the greatest movement of the underground water takes place in the upper parts of the underground stream, and that the largest quantities of water are to be procured, by suitable means, in the higher portions of the geological formation and not in the lower portions.

I observe from your reply, that you have mistaken the purport of one clause in my letter, which I intended to convey the idea that in a bore-hole which yields water at all points of its depth, a strong upward current of water would be created; if it does not yield water in its lower portion it is liable to silt up, and the bore would show, by its diminished depth, whether or not it yielded water nearer the bottom.

With reference to the difficulty of experimenting on the yield of water, I may point out that there are other ways, in addition to that of pumping, which it may be difficult to carry out, of ascertaining if the bore-hole yields a large quantity of water under the conditions of the boring at Liverpool, which would at once show whether, and what quantity of water comes from the deeper parts of the boring. This may be ascertained by experiments upon the temperature of the water; for if the bore at the great depth to which the well has been bored does yield a large quantity of water, it would be shown by the high temperature to which the whole body of water in the bore-hole would be raised; and by means of comparative temperatures at the different depths to which the well was bored, a pretty correct estimate may be formed as to the volume yielded at various depths, provision being made that the observations shall be so conducted, that the temperature shall not be interfered with by the increase of temperature generated by the working of the boring tools.

With regard to the last clause of your letter, I have

not the slightest objection to your publishing the whole of the correspondence.

I am, dear sir,
Yours faithfully,
BALDWIN LATHAM.

Mr. Alderman Bennett,
109, Shaw-street, Liverpool.

109, Shaw-street, Liverpool,
June 30th, 1879.

DEAR SIR,—In reply to your letter of the 26th, which reached me this morning, I beg to say you are in error in the deductions you draw from the information you have received. In the first place, the rise of 18 in. on a Monday morning is not at all influenced by the "Bootle well adjoining," as the pumping from this well has been continuous, Sunday and week-day, for very many months; further, the difference of height—nearly 50 ft. between the two waters, although but a few yards apart—proves, to my mind, that you can show no facts to "indicate that they both tap the same underground stream." You say, "by constant pumping, the great body of water under Liverpool has been exhausted, and it now no longer rises to the surface." In 1847, when a most exhaustive inquiry was made by Messrs. Herbert and Page, the water did not rise to the surface, nor had it done so for many years previously. Yet these gentlemen did not hesitate to say that we had an ample supply for our present and future requirements from our springs. At the date I give, not more than six or seven million gallons a day were pumped from our public and private wells, and we were told by the Mr. Lathams of that day that this quantity was rapidly diminishing, and would, in a few years, be exhausted; yet we are now raising, from the same source, more than twenty-two million gallons per day, which amount is largely added to yearly. You are entirely wrong in presuming that the site of the 1,300 ft. bore-hole, from top to bottom, is of a permeable character; and, even if it were, it would not assist you in proving your theory. It has been published, years ago, that our Red Sandstone is exhausted for, at least, 70 ft. of its depth. This being so, how do you account for the water standing in the bore-hole 53 ft. from the surface; or, in other words, 17 feet above the level of the water in the exhausted rock? All your other remarks, which are too lengthy to refute seriatim, are disproved most satisfactorily by our Borough Analyst, who assures us that water, even from such shallow bore-holes as 300 feet, is pure, wholesome, and unobjectionable, and he informs us it evidently flows from a source entirely different from that which, by local percolation, supplies our wells. With reference to the results of plugging up bore-holes at Bootle and Green-lane. I must either have expressed myself very carelessly, or you must have put a construction upon my remark which is inadmissible. You say "With reference to the experiments of which you speak as to the stopping up of the bore-holes in the wells at Bootle and Green-lane, and the small extent to which it affected the yields of the wells, this is one of the strongest pieces of evidence that could be given in support of my remarks at the Society of Arts Congress, &c.," the remainder of the sentence I need not transcribe as it is based upon fallacious data. My remark, in reply to one of yours, viz., that bore-holes in which there was no upflow were apt to silt up was in favour of your views, and I gave you as the result of my experience that the Bootle bore-hole in the old well, and the large bore at Green-lane, both of which had been plugged for a considerable time, were not permanently injured by this treatment more than about one million gallons per week—perhaps I should have been more correct in saying two millions—and had no reference whatever to the supply the wells yielded during the time the bore-holes were plugged. I quite understood your remark that if the lower portion of a bore-hole is non-yielding it is liable to silt up. I think I told you that the two bores named, when the upflow was checked by plugging, had diminished (no doubt by silting) to the extent of a million gallons a week.

As regards testing the yield of the Bootle bore-hole at different depths, the time for doing so has gone by, the pump is fixed and will be at work in a few weeks, drawing every drop of its water from a depth of many hundred feet, and I hope and believe from a source which will convince us all, is pure, wholesome, and abundant. It is my intention (as you have not the slightest objection) to publish the whole of the correspondence, as I look upon the obtaining of a deep bore-hole supply of water for drinking and domestic use as most essential for improving the health of the people, and abating the vice of drunkenness. For these and other reasons, economy being one, I feel most anxious to draw the attention of the public to this important matter. A comparatively small sum judiciously spent in testing by boring, what quality and quantity different localities will yield, may, in many cases, insure a supply of water to a large town, free of all suspicion of organic contamination, and at a cost not exceeding the money lost in interest alone during the construction of water-shed works for the same purpose. I do not undervalue the importance of a rain-water supply for manufacturers and others; there are many ways of procuring this water sufficiently pure at a small cost.

Yours truly,
WILLIAM BENNETT.

Baldwin Latham, Esq., C.E.

Bootle, 30th June, 1879.

DEAR SIR,—I send you the depths at which the water stood at the time of Mr. B. Latham's visit, and at the last takings.

1878.—When Mr. Latham was here, 52 ft. 6 in.; and on Aug. 12th, 51 ft. 1 in.

1879.—Jan. 10th, 50 ft. 3 in.; Jan. 29th, 50 ft. 5 in.; Feb. 5th, 50 ft. 4½ in.; Feb. 12th, 50 ft. 7 in.; Feb. 19th, 50 ft. 2 in.; Feb. 24th, 50 ft. 6 in.; March 5th, 50 ft. Since which it has not been taken, as the clack is in its place in the pump barrel.

These statistics are, I think, more to the point than the argument about facts which Mr. Latham may dispute.

Your truly,
A. W. PARISH.

W. Bennett, Esq.

ELECTRIC LIGHTING.

The following report of the Select Committee of the House of Commons appointed "to consider whether it is desirable to authorise municipal corporations or other local authorities to adopt any schemes for lighting by electricity, and to consider how far, and under what conditions, if at all, gas or other public companies should be authorised to supply light by electricity," has been issued:—

"The general nature of the electric light has been well explained in the evidence of Professor Tyndall, Sir William Thomson, Dr. Siemens, Dr. Hopkinson, and others. It is an evolution of scientific discovery which has been in active progress during the whole of this century. Essentially the electric light is produced by the transformation of energy either through chemical or mechanical means. The energy may be derived from a natural force, as, for instance, a waterfall, or through combustion of a material in the cells of a voltaic battery, or of fuel in a furnace. The energy being converted into an electric current may be used to manifest electric light by passing between carbon points or by rendering incandescent solid bodies, such as iridium. A remarkable feature of the electric light is that it produces a transformation of energy in a singularly complete manner. Thus the energy of one-horse power may be converted into gaslight, and yields

a luminosity equal to 12-candle power. But the same amount of energy transformed into electric light produces 1,600-candle power. It is not, therefore, surprising that while many practical witnesses see serious difficulties in the speedy adaptation of the electric light to useful purposes of illumination, the scientific witnesses see in this economy of force the means of great industrial development, and believe that in the future it is destined to take a leading part in public and private illumination. There is one point on which all witnesses concurred, that its use would produce little of that vitiated air which is largely formed by the products of combustion of ordinary illuminants.

"Scientific witnesses also considered that, in the future, the electric current might be extensively used to transmit power as well as light to considerable distances; so that the power applied to mechanical purposes during the day might be made available for light during the night. Your committee only mention these opinions, as showing the importance of allowing full development to a practical application of electricity, which is believed, by competent witnesses, to have future important bearings on industry.

"So far as the practical application of the electric light has already gone, there seems to be no reason to doubt that it has established itself for lighthouse illumination, and is fitted to illumine large symmetrical places, such as squares, public halls, railway stations, and workshops. It is used in Paris for lighting shops which require a light by which different colours may be distinguished, and has recently been used in England for the same purpose with satisfactory results. Many trials have been made for street illumination with greater or less success.

"Compared with gas, the economy for equal illumination does not yet appear to be conclusively established. Although in some cases the relative economy for equal candle-power is on the side of the electric light, yet in other cases gas illumination of equal intensity has the advantage. Unquestionably, the electric light has not made that progress which would enable it in its present condition to enter into general competition with gas for the ordinary purposes of domestic supply. In large establishments the motors necessary to produce the electric light may be readily provided, but, so far as we have received evidence, no system of central origin and distribution suitable to houses of moderate size has hitherto been established.

"In considering how far the Legislature should intervene in the present condition of electric lighting, your committee would observe generally that in a system which is developing with remarkable rapidity, it would be lamentable if there were any legislative restrictions calculated to interfere with that development. Your committee, however, are not in a position to make recommendations for conditions which may hereafter arise, but at present do not exist, as to the distribution of electric currents for lighting private houses from a central source of power. No legislative powers are required to enable large establishments, such as theatres, halls, or workshops, to generate electricity for their own use.

"If corporations and other local authorities have not power, under existing statutes, to take up streets and lay wires for street lighting or other public uses of the electric light, your committee think that ample power should be given them for this purpose. There seems to be some conflict of evidence as to whether the existing powers are sufficient or not. But even in regard to local authorities it would be necessary to impose restrictions upon placing the wires too near the telegraph wires used by the Post-office, as the transmitting power of the latter would be injuriously affected by the too close proximity of the powerful electric currents needed for producing light.

"Gas companies, in the opinion of your committee, have no special claims to be considered as the future distributors of electric light. They possess no monopoly of lighting public streets or private houses beyond that which is given to them by their power of laying pipes in streets. Electric light committed to their care might have a slow development. Besides, though gas companies are likely to benefit by the supply of gas to gas-engines, which are well suited as machines for producing electric light, the general processes of gas manufacture and supply are quite unlike those needed for the production of electricity as a motor or illuminant.

"Your committee, however, do not consider that the time has yet arrived to give general powers to private electric companies to break up the streets, unless by consent of the local authorities. It is, however, desirable that local authorities should have power to give facilities to companies or private individuals to conduct experiments. When the progress of invention brings a demand for facilities to transmit electricity as a source of power and light from a common centre for manufacturing and domestic purposes, then, no doubt, the public must receive compensating advantages for a monopoly of the use of the streets. As the time for this has not arrived, your committee do not enter into this subject further in detail than to say that in such a case it might be expedient to give to the municipal authority a preference during a limited period to control the distribution and use of the electric light, and failing their acceptance of such a preference, that any monopoly given to a private company should be restricted to the short period required to remunerate them for the undertaking, with a reversionary right in the municipal authority to purchase the plant and machinery on easy terms. But, at the present time, your committee do not consider that any further specific recommendation is necessary than that the local authorities should have full powers to use the electric light for purposes of public illumination; and that the Legislature should show its willingness, when the demand arises, to give all reasonable powers for the full development of electricity as a source of power and light."

CORRESPONDENCE.

PATENT-LAW.

To my great regret, I have been prevented attending the last discussion on Mr. Wise's excellent paper on the Government Patent Bill, and, therefore, ask permission to add a few remarks about preliminary examination. The idea of such examination seems still to exercise much fascination on a considerable part of the general public, just as if inventors had not to pass examinations enough as things stand at present. I know this assertion may seem startling to many uninitiated, but I will show that, at present, every inventor has to pass three examinations, as severe as any that fall to the lot of suffering mortals.

1. The first is, when the inventor applies to a professional draftsman to have his designs put into working shape, or to a practical engineer to have it constructed in an experimental form. Practical men are not remiss in scanning every innovation with distrustful eyes, and actual trial only too often discloses fatal difficulties, which render inventions unworkable. No doubt a great many schemes already break down at this early stage.

2. The second examination occurs on the publication of the invention, when all parties aggrieved by the new comer—that is the rival patentees and interested manufacturers—unite to drive the intruder off their own domain, or at least to confine the scheme to the narrowest

possible limits. Any invention without true value rarely survives these two trials; and, so far, the weeding-out process is considerable. However, with a great deal of patience, ingenuity, and hard cash, they may be got over.

3. Not so the third examination, where neither patronage, nor money interest, nor any influence whatsoever can avail the inventor. I mean the examination which he has to undergo when the public is invited to decide whether the invention is worth paying for, or whether it may be left to the sole enjoyment of its sanguine progenitor, with all attendant expenses, and lost time and labour. I venture to say, that all the ingenuity of our law makers could not devise a more searching, rigorous, or effective series of examinations than those enumerated above. No doubt a more formal ceremony might be arranged to satisfy the official mind and the outside world, but I fail to see that the few moments spent during such examinations for mere show could at all compare with the efficacious trials actually obtaining in practical life. But I should very much like to see preliminary examination replaced by another process, not exactly an examination passed by the Patent officials before the inventor, but something tending that way. I mean that every inventor who has obtained provisional protection and paid his fee should have the privilege to consult the proper Patent officials—delegated for this special purpose—in order to be informed what patents are already in existence bearing on the same subject as his own invention, and in how far the latter may be affected by the former. This consultation to be considered as a privileged communication, exactly as between attorney and client, so that an inventor may fearlessly disclose the whole of his plans and designs, and either abandon or modify them according to the state of other patents in the same field. I believe that almost every inventor would gladly and gratefully avail himself of such privilege, and that this voluntary examination, or search, would result to far greater benefit of all parties concerned, than the intended preliminary examination, where examiner and examined necessarily fight shy of each other. In this way the Patent-office would become more of an impartial and trusted guardian of the interests of the outside public on the one hand, and of the rival inventors on the other. In fact, it might then occupy an analogous place as in the commercial world the sworn-brokers are supposed to hold, for seeing that dealing goes on fairly, as between buyer and seller, and for bringing the parties together.

R. J. Werotte.

28, Finborough-road, S.W.
June 21st, 1879.

The Russian Imperial Technical Association has presented a memorial to the Minister of the Interior calling his attention to the influx of foremen from foreign parts, and suggesting that steps should be taken to discover the reasons that lead them to compete so successfully with those of native birth. Throughout the greater part of the country the workmen employed in any trade requiring skill are found largely under the control of foreigners, and the association estimates in the department of mechanics alone there are as many as 800 Englishmen.

M. Clamond has been experimenting in the production of the electric light by means of the thermo-electric pile. It is stated he has succeeded in producing a current strong enough to work a Serrin lamp with tolerable success. The expense is only seven kilogrammes of coals per hour.

Erratum.—Page 691, column 1, line 17, *for* "by compulsory inspection," *read*, "by courteous inquiry than by compulsory inspection."

OBITUARY.

Sir W. Fothergill Cooke.—Sir William Fothergill Cooke, the eminent electrician, who died on the 25th June, was a member of the Society of Arts of long standing. He was born at Ealing in 1806, and after receiving his education at Durham, and at the University of Edinburgh, he commenced life by joining the East Indian Army in 1826. On his return to Europe, after leaving the Army, he studied anatomy and physiology at Paris and Heidelberg, and occupied himself in modelling anatomical dissections for the illustration of his father's (William Cooke, M.D.) lectures at the University of Durham. It was during his stay at Heidelberg that his attention was first directed in March, 1836, to the adaptation of electricity to a practical system of telegraphing, and in the following month he came to England to perfect his plans and instruments. In February, 1837, he was introduced to Professor (afterwards Sir Charles) Wheatstone, who had then made several important discoveries with the object of transmitting intelligence by electricity. In May, 1837, Messrs. Cooke and Wheatstone took out a joint English patent on a footing of equality for their existing inventions, and the terms of their partnership were more exactly defined and confirmed in November, 1837, by a partnership deed. Cooke became a director of the newly-formed Telegraph Company, and the first telegraph line in England was constructed from Paddington to West Drayton on the Great Western Railway in 1838-9. In 1843 Cooke was elected a member of the Society, and, in 1867, he and Wheatstone were awarded the Albert Medal, in recognition of their joint labours in establishing the first electric telegraph. He received the honour of knighthood on 11th November, 1869, and on 25th July, 1871, he obtained a Civil-list pension of £100. Sir W. F. Cooke was the author of several works, and, in 1856 and 1867, he read papers before the Society. The first was, "On the Utilisation of Sewage of Towns, by the Deodorising Process established at Leicester;" and the second, "On New Machinery for Cutting, Tunnelling, Quarrying, and Facing Slate, Stone, and Marbles."

NOTICES.

SANITARY CONFERENCE.

The Pamphlet containing a full report of the papers and proceedings of the late Conference on National Water Supply, Disposal of Sewage, and Health, will be published shortly, price 2s. 6d.

Applications for copies of the Report should be addressed to the Secretary.

MEETINGS FOR THE ENSUING WEEK.

Mon., July 7th...Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.
Asiatic, 22, Albemarle-street, W., 3 p.m.
Social Science Association, and Society for Promoting the Amendment of the Law, 1, Adam-street, W.C., 8 p.m. Mr. Manley Hopkins, "Street Accidents."

Tues., July 8th...Royal Horticultural, South Kensington, S.W., 1 p.m.

Wed., July 9th...Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Thur., July 10th...Royal Historical, 11, Chandos-street, W., 8 p.m. 1. Nicholas Casimir, Baron de Bogoushevsky, "The English in Muscovy during the Sixteenth Century." (Part II.) 2. Rev. R. Pennington, "The Holy Roman Empire; or the Causes of the Disintegration of Germany."

Fri., July 11th. ... Quekett Microscopical Club, University College, W.C., 8 p.m.

Sat., July 12th...Royal Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,390. Vol. XXVII.

FRIDAY, JULY 11, 1879.

All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

LIBRARY COMMITTEE.

The following report of the Library Committee was submitted to the Council at the last meeting, and approved:—

After careful consideration of the question, the Committee are of opinion that the MS. Catalogue at present in use is sufficient for all purposes of reference. The Library is far from complete. It consists mainly of old books, Transactions of Scientific Societies, and Periodical Publications, and a large expenditure of money would be necessary to make it really available for purposes of scientific reference. When there are so many existing libraries in London, it has never seemed advisable to the Council to spend largely upon the Library of the Society, but rather to devote to public objects whatever funds the Society had available. If in future it be thought advisable to improve the Library by a large purchase of books relating to the objects fostered by the Society, the question of printing a catalogue will probably again arise, but at present the Committee think that the expenditure of one or two hundred pounds in the preparation and printing of a catalogue would be inexpedient. With regard to the other question referred to them, that of opening the Library in the evening, the Committee find that for the past two years it has been the practice to keep the room open on Wednesday evenings from seven till ten during the Session, but that very few members have used it. Considering that members are able to borrow books from the Library, the Committee do not see that much advantage would accrue to them from the opening of the Library in the evening, and in view of the considerable additional expenditure necessary for lighting and extra attendance, they are unable to recommend it. As, however, a wish has been expressed by some members that the experiment might be tried, they recommend the opening of the small Reading-room on all evenings when the Society's meetings are held, during the continuance of the meetings.

NATIONAL WATER SUPPLY.

SUGGESTIONS FOR DIVIDING ENGLAND AND WALES INTO WATERSHED DISTRICTS.

Essay by Joseph Lucas.

Motto—"Gutta cavat lapidem, non vi, sed sæpe cadendo."

AWARDED A SILVER MEDAL.

SYNOPSIS OF PAPER OF SUGGESTIONS.

A. Prefatory. Areas and Boundaries of Districts.
Objections to existing Areas and Boundaries.
B. Suggestions for New Districts.
i. As to Watershed Areas.
ii. Illustrations of Grouping ditto
iii. Subdivision of ditto.
C. Watershed Boards.
D. (*a*.) Commissioners' Districts.
(*b*.) Sub-Commissioners' Districts.
(*a*.) Limits of Northern, Midland, and Southern Commissioners' Districts.
(*b*.) Limits of Sub-Commissioners' Districts.
E. Rainfall.
F. Geology.
G. Population.
H. Constitution of Watershed Boards.
i. Respecting the Claims of Boards of Guardians to be Represented.
ii. As to the Representation of Landowners.
iii. As to the Representation of Towns.
iv. Miscellaneous Suggestions, bearing on Constitution of Boards.
J. Local Government Board as a Central Authority.
K. Commissioners of Watershed Boards.
L. Engineering Staff to Watershed Boards.
M. Provisions in River Conservancy Bill which Relate to Areas and Boundaries, and are Adapted, as Modified, to Watershed Boards. Clauses 1 to 7 (inclusive), 33, 37, 39, 40, and 41.
N. Resume.
O. Miscellaneous Considerations, Tending to the Establishment of Watershed Boards.
P. As to the Advisability of Interposing Commissioners between Watershed Boards and the Local Government Board.
Q. Province of the Three Commissioners.
R. Duties of Watershed Boards.
S. Powers of Ditto.
T. Duties of Sub-Commissioners.
U. President of Local Government Board to Retain Present Functions as Regards Suggested Watershed Boards.
V. Respecting Appointment of Commissioners.
W. General View of Advantages of Proposed Arrangements.
X. Conclusion.
Appendixes.
A. List of Authorities.
B. Table I. Showing Watershed Basins, Areas, Rainfall, and Geology of Commissioners' and Sub-Commissioners' Districts, and of 36 Groups of Watersheds. Table II. Showing Counties and Parts of Counties, and Populations, in Commissioners' and Sub-Commissioners' Districts. Table III. Summary of Tables I. and II.

AREAS AND BOUNDARIES OF DISTRICTS.

A.—Objections to Existing Areas and Boundaries.

"Existing boundaries are altogether independent of sanitary considerations*. They frequently cut a row of houses in half, and an urban district terminates in the middle of a street."† . . . "Several boundaries of adjoining districts sometimes converge and meet in the centre of the most populated part of the district‡." . . "If areas are extensive, they constantly lead to complaints, on the part of sections of the community of rural districts, that practically they are not represented on the governing body, that the meetings of the authority are far away at the other end of the districts, and that no interest whatever is taken in their concerns by gentlemen who live at a distance§." . . . "On the other hand, if areas be small, it is impossible to provide and properly remunerate officers duly qualified for the important duties they should discharge‖."

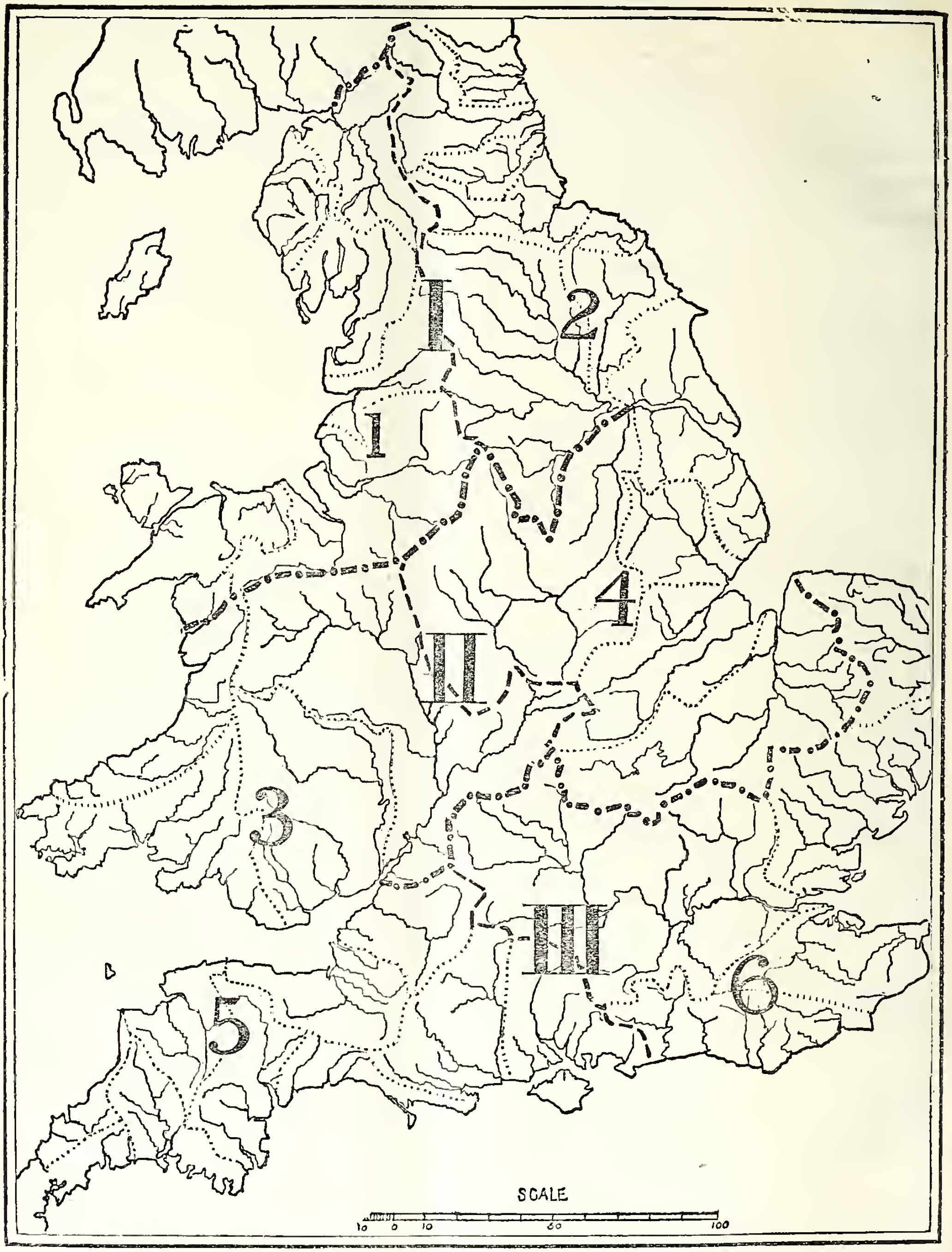
Local administration under ¶ "central superintendence" was the gist of the recommendation of the fertile report of the Sanitary Commissioners of 1869. They say:—

"The smallness of the parochial unit minimises the material for public officers. Imperfect local administration has been the natural result. Local administration must be maintained, but simplified, strengthened, and set in motion.**"

In consequence of these recommendations,†† the areas of unions were made sanitary districts, and Board of Guardians were made sanitary authorities, while the Local Government Board was created and made the central authority. [34 and 35 Vict., c. 70.]‡‡

In this, the substantial part of their recommendation, that "local administration must be maintained, but simplified, strengthened, and set in motion" appears to have been swamped. While there is still wanting "a real motive power, and

* "The Working of the Sanitary Acts in Rural Districts," by W. H. Michael. (Transact. Inst. Surveyors, Vol. VIII., p. 363.)
† *Ibid*, p. 365. ‡ *Ibid*, p. 369. § *Ibid*, p. 369. ‖ *Ibid*, p. 369.
¶ Royal Sanitary Commission, 1869, Report, p. 16.
** *Ibid*, p. 16. †† *Ibid*, p. 24. ‡‡ *Ibid*, p. 31.



Map of Districts Proposed by Joseph Lucas.

Boundaries of Commissioners' Districts (I, II, III), thus:— ▬ • ▬ • ▬

,, of Sub-Commissioners' Districts' (1, 2, 3, 4, 5, 6), thus: — — — —

,, of Groups of Basins, thus:— ......

an authority to be referred to for guidance and assistance by all the sanitary authorities,* some organisation† corresponding to the Ordnance Survey and the Geological Survey, which should really bring before the local bodies, before they acted, the means by which they might act, and the resources with which they had to deal," the Local Government Board, for want of the very same kind of information, being unable to suggest a remedy applicable to such small areas of collection

* Royal Sanitary Commission, 1869, Report, p. 81.

† Congress on National Water Supply; Disc., G. W. Child, p. 4.

and distribution of water supply, and of taxation, as those with which they frequently have to deal, have found it impracticable* to put into execution the compulsory powers conferred upon it by the Public Health Act (1875.) [38, 39 Vict. c. 55.]

It simply comes to this, where compulsion would be necessary it is because the areas are too small for the authorities to act without pressure, and for the same reason too small to admit of that pressure being effectively applied; and, where areas are large enough, no pressure has been found to be necessary.

B.—Suggestions as to New Districts.

(i.) *As to Watershed Areas.*—Popular opinion, during the last fifteen years, has ripened to a point at which all authorities are agreed as to the necessity of making the watershed area the unit of administration for water supply (among other subjects),† and I am of opinion that, for the purposes of water supply, there should be districts and subdistricts, formed by (‡) the grouping and (§) the subdivision of these units.

(ii.) *Illustration of Grouping on a large scale* (*an extreme instance*).—(1.) On the east coast and elsewhere, there are several small basins containing large and growing towns, such as Colchester, supplied from wells sunk in the chalk (and tertiary strata), whose gathering ground is at its outcrop, miles to the west, and which has a well-known extensive range. There are numbers of these little basins east of the chalk range, which form a natural group from the southern limit of the Thames basin to the Wash. The same *régime* obtains on the coast of Lincolnshire and of Yorkshire. The several basins draw upon a common source, and should exhaust their resources upon one principle, and subject to Watershed Boards ; || the administrative machinery should be so designed as to admit of their doing so. If it ever becomes necessary for them to look further west, an extended application of the powers conferred upon the Local Government Board [38 and 39 Vict., c. 55, 270, 279] to alter the boundaries,¶ effect the union of districts, and to enable one to supply another [38 and 39 Vict., c. 55, 61] would be necessary. This is given as an extreme instance of a case that may often arise, and in explanation of many of the provisions suggested below, all of which are extensions of powers already contained in Acts of Parliament.

(iii.) *Subdivision.*—Subdivision of basins would follow Clause 33 of the Rivers Conservancy Bill, 1879.

C.—Watershed Boards.

I therefore suggest again, what has often been suggested before by others, viz., the creation of Watershed Boards, to deal with the question of water supply, subject to the constitution, control, and restrictions, and with the powers and duties, suggested below.

D.—Commissioners' Districts.

(*a.*) *Commissioners' Districts.* — England and Wales are mapped out into three Commissioners' districts, and these three districts are further divided into (*b.*) Sub-Commissioners' districts, each consisting of aggregates of watershed basins, administered by Watershed Boards. (*a.*) The north of England is made one Commissioner's district, as shown on the map*; the Midland Counties and Wales another;† and the Southern Counties a third,‡ on the principle that the rivers flow east and west, and the mountains and geological lines run north and south. By this arrangement, each Commissioner's district gets its full share of mountain, plain, and geological strata. Again, the three localities of highest rainfall, the lake mountains, the Welsh mountains, and Dartmoor, accord well with these divisions, each of which gets its share of the wettest and driest areas.

(*b.*) *Sub-Commissioners' Districts.*—The Sub-Commissioners' districts are formed by dividing each of the east and west belts, or zones, formed by the the three Commissioners' districts, into two parts, separated by the north and south backbone watershed lines, in the Northern and Midland districts, and the southern limit of the Thames basins as far as, and then along, the western limit of the Arun basin, in the Southern districts.

E.—Rainfall.

The rainfall of the Commissioners' and Sub-Commissioners' districts is made to appear upon the accompanying map ; and is also stated in detail in Tables 1 and 3 of Appendix B§, the authority in each case, of course, being Mr. Symons.

F.—Geology.

As the areas of administration of the proposed Watershed Boards have to be determined, not by these essays, but by the inhabitants of the several watersheds, I have arranged the 215 watersheds given on the ordnance map into 36 natural groups, each of which groups stands so related to the watershed basins contained in it, that a statement of the rainfall and geology of the group applies to every basin within the group. Several of these groups are single basins. The groups are only for the purpose of illustrating the geology and rainfall of the basins, and are not suggested "districts."

G.—Population.

Table 2, Appendix B, shows the population of each Sub-Commissioner's district, and of each county aud part of county in the district.

The population of the suggested Watershed Boards' districts cannot, I take it, be stated until the populations have determined the districts. What may be the least area and the least population capable of managing its own water supply would be difficult questions to answer ; and, I doubt not, that any suggested appointment of favourite gathering grounds would prove unacceptable to the interests most affected. For instance, the Dee falls into a natural group with the populous basin of the Mersey, and if the matter could have been prescribed, the Dee basin would long ago have supplied the Mersey basin.

This essay suggests the creation of facilities for establishing Watershed Boards, on the lines of the Rivers Conservancy Bill, but does not go so far as to

* Congress, 1878 :—Dr. G. W. Child, p. 7 ; Dr. Syson, p. 8.

† 1. Report Roy. San. Com., 1869, p. 39. 2. Lord Robert Montagu, p. 339. 3. Report of Roy. San. Com. on R. Clyde, 1876, pp. xxvii., xxviii. 4. Report Conservancy Boards Committee House of Lords, 1877, pp. iv., v. 4*a.* Rivers Conservancy Bill, 1879. 5. And numerous private authors.

‡ Rivers Conservancy Bill, clauses 37, 40.

§ Rivers Conservancy Bill, clause 33.

|| Report Roy. San. Com., 1869, p. 39.

¶ Rivers Conservancy Bill, 1879, clauses 39, 40.

* 1. Northern Commissioner's District.

† 2. Midland Commissioner's District.

‡ 3. Southern Commissioner's District.

§ Appendix B., Tables 1 and 3.

prescribe the areas of these districts, which will all have to be fought for.

H.—Constitution of Watershed Boards.

(i.) *Respecting the Claims of Boards of Guardians to be represented on the Boards.*—Though much abuse has been hurled at Boards of Guardians since their erection into rural sanitary authorities, it is certain that the remedies for the evils complained of have neither been cheap nor easily applied in many cases; and the Boards were ably defended by Dr. Syson, at the Congress on National Water Supply, 1878.* He says:—

"They ought to elevate Boards of Guardians and sanitary authorities, by entrusting them with more power. He believed local sanitary authorities in the country had done their duty very fairly, and, to a certain extent, bravely; but the great obstacle was the Local Government Board, which would not allow them to work without such an amount of red tape that they dare not attempt it."

Both evidently being in the same dilemma, not knowing what to do.

Mr. Vigers, a member of a rural sanitary authority, or Board of Guardians, having direction of a union of 44,406 acres, with a population of 22,949 persons, including several perfectly rural districts, says† :—

"The district was managed by a Board, sitting once a fortnight, and the representatives who formed the Board had as much sympathy with each other as could well be imagined. Those who represented the rural districts came there, apparently, for the express purpose of resisting any proposal which appeared to involve expenditure of money, so that anything which was proposed for the benefit of the towns and villages was swamped at once. There was not a sufficient number of Guardians who took interest in any plans of improvement." . . . . "His own opinion was" . . . . "that instead of similar matters being left in the hands of Boards of Guardians, there should be a Board elected by the owners of property in the several districts."‡

He then quotes from Mr. Michael's paper:—

"'Whatever may be the character and ability of Sanitary Boards, it is upon the ability and character of their officers that success must depend.' He thoroughly endorsed that remark. It was utterly impossible for a Board of Guardians, meeting only once a fortnight, to even partially master the difficulties with which they had to deal."

Now, as many Boards of Guardians appear to be provided with a sanitary officer, who is not paid to devote his whole time to his work, it is not likely that he, any more than they, will be able to grapple with difficulties which have baffled the Local Government Board, with all its scientific appliances. It is true there is a scientific staff attached to that Board, but it is too lofty, and out of the reach of rural sanitary authorities. I submit, therefore, that the case of incapacity against Boards of Guardians is not proven, for whatever proves them to be incapable proves equally the inefficacy of the antidote in the Local Government Board.

Interests Represented on Watershed Boards.	*How Represented.*
Urban Sanitary Authorities.	One or more elected member.
Rural ,, ,,	,, ,, ,,
Owners and occupiers of land.	As in Rivers Conservancy Bill.
Town Councils.	As in Public Health Act, 1875 [38 and 39 Vic., c. 55, 6].

* Congress on National Water Supply, 1878. Disc., p. 9.

† "The Working of the Sanitary Acts in Rural Districts," by W. H. Michael. Trans. Inst. Surveyors, vol. viii., p. 363.

‡ "Sedgwick," pages 390, 398.

I, therefore, suggest that one or more representatives from each Board of Guardians within the watershed area should sit upon the Watershed Board, according to the rateable value of the property within that part of the union lying within the watershed area.

2. *As to the Representation of Landowners.*—That the landowners be represented in a manner similar to that adopted in the Rivers Conservancy Bill, 1879, now before the House of Lords, as modified below. Clause 6 of that Bill meets all requirements for the formation of Watershed Boards for water supply, as far as regards sanitary authorities and landowners.

3. *As to the Representation of Towns.*—In any Watershed Board for water supply, however, towns must be represented. I would add to the above constituents Town Councils, represented in proportion to rateable value of property within their districts.

4. *Miscellaneous Suggestions bearing on the Constitution of Watershed Boards.*—The only suggestions I have discovered bearing on the difficult question of the constitution of watershed authorities—upon which the extent of the area of administration to a certain extent depends—are those contained in the paper of Lord Robert Montagu on Watershed Boards;* in Sir John Hawkshaw's report on the Clyde;† and in the parallel case of the Rivers' Conservancy Bill, 1879.

J.—The Local Government Board as a Central Authority.

It seems to commend itself that the Local Government Board should remain a central authority, to which Watershed Boards, under the wing of their several Commissioners should be affiliated.

K.—Commissioners of Watershed Boards.

The Local Government Board being above the three Commissioners, would then act not only as a Court of Reference and of Appeal, but would, by presiding in common over all the affiliated Watershed Boards, secure "uniformity of action."‡ Sir John Hawkshaw, in his report on the Clyde,§ in recommending the appointment of Commissioners of the Clyde, having jurisdiction over the whole basin, rightly estimates the value of this, for he recommends similar Commissions for all other basins, "with an officer in common, to secure uniformity of action."‖ For "an officer in common," whose position would be far from enviable, I would interpose the Commissioners, leaving the Local Government Board, with their scientific staff, just as it is.

L.—As to the Appointment of an Engineer and Staff to Watershed Board.

Now, as Mr. Vigers and Mr. Michael remark, it it is upon the character and ability of the officers of the Board that success must depend, and it is necessary that the whole time of those officers should be given to their work. Again, since the

* Lord Robert Montague, paper on "Watershed Boards." Report Royal Sanitary Commission, p. 347.

† Sir John Hawkshaw, report on Pollution of Clyde, p. xxviii. Public Health Act, 1875 [38 & 39 Vict., c. 55, 6].

‡ Letter on Watershed Boards, Lord Robert Montagu, Royal Sanitary Com., p. 347. The Working of the Sanitary Acts in Rural Districts, W. H Michael, Transac. Inst. Surveyors, vol. viii. p. 375.

§ Report of Royal Com on R. Clyde. ‖ P. xxix.

scientific staff of the Local Government Board is too small to give constant, detailed, and comprehensive attention to all parts of the 37,319,221 acres in England and Wales, and of too lofty a description to do drudgery for Watershed Boards, and not possessed of the necessary scientific knowledge of the hydrogeology of England and Wales, and from being formed for, and employed upon, other work, I think that each Watershed Board should have its own engineering, but not scientific staff.*

M.—Suggestions Relating to Areas and Boundaries, as Part of a Bill to Make Provision for the Administration of Water Supply.—Adapted with Modifications from the Rivers Conservancy Bill.

Preliminary.

1. This Act may be cited as the Watershed Boards Act.
2. This Act shall not extend to Scotland or Ireland.

Proceedings for establishing Watershed Board.

3. The Local Government Board may, on application, and after local inquiry, and with the sanction of Parliament, establish a local Watershed Board, for the administration of water supply, in a district consisting of the whole or any part of the basin of the river, or the basins of the rivers.

The application may be made by any ten or more owners of land, of an aggregate rateable value of one thousand pounds, within the basin or basins, or by any sanitary or municipal authority whose district is wholly or partly within the basin or basins.

The application shall describe, by reference to a map or otherwise, the district for which it is proposed that the Watershed Board be established, and shall be in such form, and contain such particulars, and be accompanied by such information as the Local Government Board from time to time require.

4. The Local Government shall take into consideration any application made to them for the establishment of a Watershed Board, and, on being satisfied that a *prima facie* case has been made out for the establishment of the Board, and that sufficient provision has been made for the expenses which may be be incurred by the Local Government Board in connection with any local inquiry directed under this section, shall direct one of their inspectors to hold a local inquiry as to the expediency of establishing a Board, and as to the limits which should be assigned for the district of the Board.

Notice of the inquiry shall be given by advertisement and otherwise as the Local Government Board direct.

5. (1.) If after the local inquiry it appears to the Local Government Board expedient that a Watershed Board should be established for the proposed district, or for any part of the proposed district, with or without, in either case, the addition of any adjacent area, the Local Government Board shall prepare a draft provisional order for the establishment of the Watershed Board, defining the limits of the district, specifying the lands, if any, excepted from the district, and the lands, if any, exempted from the rates of the board, declaring the number, and (subject to the provisions of this Act) the constitution of the Watershed Board.

(2.) The Local Government Board shall cause printed copies of the draft provisional order to be deposited with the clerks of the several sanitary authorities for districts wholly or partly comprised in the district defined by the draft order, and the copies so deposited shall be open to inspection, without fee, by all owners of land and ratepayers within that district. The Board shall also cause notice to be published of the deposit and of the time and place, or times and places, at which one of their inspectors will attend to hear any objections to the draft order.

* National Water Supply Congress, 1878:—Sir H. Cole, p. 39 Joseph Parry, p. 58.

(3.) After receiving the report of their inspector with respect to the draft order, the Local Government Board may, subject to the provisions of this Act, make the provisional order, with such additions and modifications as to them seem expedient, but the order so made shall not be of any validity until it is confirmed by Act of Parliament.

Constitution of Watershed Board.

6. (1.) A Watershed Board shall consist of life members and elective members.

(2.) Life members shall be in the first instance named in the order establishing the Board.

(3.) Elective members shall be elected from time to time by the sanitary authorities, for districts wholly or partly within the district of the Board, and each sanitary authority shall elect at least one member.

(4). The life members shall not be less than one-third of the total number of members of the Board. Each life member must be qualified, by being the owner of land within the district of the Board, of an annual rateable value of three hundred pounds. He shall, subject to the provisions of this Act, be entitled to hold office for life. On his office becoming vacant, the vacancy shall, as soon as may be, be filled by the Board.

(5.) The elective members, or, if more than one member is elected by any authority, then not less than one-half of the members elected by that authority, must be severally qualified by being owners of land within the district of the Board of an aggregate rateable value of one hundred pounds. The elective members not so qualified must either be, or be qualified to be, members of the authorities by whom they are severally elected. The term of office of each elective member shall be three years, but he may, if qualified, be re-elected.

7. (1.) On the passing of the Act confirming an order for the establishment of a Watershed Board, and within the time, if any, limited by the order, the Board shall be formed in manner directed by the order.

(2.) A Watershed Board, when formed, shall be a body corporate bearing the name given to it by the order by which it is established, with perpetual succession and a common seal, and having power to hold land for the purpose of this Act without any licence in mortmain.

Miscellaneous Provisions.

A Watershed Board may divide their district into sub-districts, consisting of areas drained by any tributary stream or streams flowing into any river within their district, and may from time to time alter the boundaries of any such sub-district.

A Watershed Board may, from time to time, appoint out of their own number as many persons as they think fit, for any purposes of this Act which in the opinion of the Board would be better regulated and managed by means of a committee. But a committee so appointed shall in no case be authorised to borrow any money, to make any rate, or to enter into any contract, and shall be subject to any regulations and restrictions which may be imposed by the Board, &c., &c.

Every Watershed Board shall make an annual report, in such form and at such time as the Local Government Board from time to time direct, of all works executed, and of all sums received and disbursements made by them under and for the purposes of this Act during the preceding year, and shall send a copy to the Board, and publish another copy in some local newspaper circulating in their district.

A Watershed Board may be established for, and its district may include the basins of, two or more rivers.

The Local Government Board may from time to time, by provisional order, alter the boundaries of a Watershed Board district, and adjust any rights or liabilities affected by the alteration.

The Local Government Board may from time to

time, by provisional order, on the application of any two or more Watershed Boards, dissolve them as separate Boards, and reconstitute them as a single Board for a district consisting of the districts of the former boards, and make such provisions as to the mode of constituting the new Board as may be necessary or expedient for that purpose.

Thereupon, subject to any special provisions contained in the order, the rights, powers, estates, and property vested in the old boards shall vest in the new board, and all the liabilities and obligations of the old boards shall be borne by the new board, and the old boards shall be discharged from all such liabilities and obligations, and the new board shall be deemed to be the successors of each of the old boards.

Any sanitary authority appointed, or acting by or under any Act of Parliament for any district comprised wholly or partially within the district of a Watershed Board, whether the powers of the authority under the Act do or do not extend beyond the district of the Watershed Board, may, if it seems to them expedient, at a meeting called for that purpose, transfer to the Watershed Board, with the consent of that Board, but not otherwise, all the rights, powers, estates, property, and liabilities of the authority under the Act or otherwise, &c.

N.—Resume.

We should thus have Watershed Boards established over one or more river basins, by provisional order of the Local Government Board, after due local inquiry, upon application, of landowners, sanitary authorities, or towns, situated within the watershed basin, or basins.

O.—Miscellaneous Considerations Tending to the Establishment of Watershed Boards.

There can be no doubt that if the dual interests of town and country, as above suggested, were brought under the operation of one Board, the matter would work well and quickly.

For sundry reasons connected with rating, taken in connection with the accepted principles* of (1) the expediency and advantage of consolidating the water supply under public control; (2) the advantage of making it embrace large areas, especially in reference to the groups of towns in manufacturing districts; and (3) the encouragement given to small towns and rural districts by the provision† recently applied in the case of the Thirlmere scheme, that places along the line of an aqueduct may be supplied therefrom. Towns as well as country districts would seek the establishment of Watershed Boards.

P.—As to Advisability of Interposing Commissioners between Watershed Boards and the Local Government Board.

Now, from the very large number of Watershed Boards (even when reduced to a possible minimum by grouping, of about 51) it would appear expedient to interpose between them and the Local Government Board, a Commission of three, composed in the following manner:—

1. A Commissioner of the Northern Boards. 2. A. Commissioner of the Midland Boards. 3. A Commissioner of the Southern Boards.—Each having charge of the district shown on the accompanying map.

Q.—Province of the Three Commissioners.

The province of the three Commissioners would be—(1), To answer inquiries by the Local Government Board, respecting their large districts; (2), To make annual reports to the Local Government Board; (3), To be consulted by the Watershed Boards in their districts, and to confer with them and aid them in their deliberations upon the merits of new schemes, the pollutions of underground waters, and other questions.

R.—Duties of Watershed Boards.

The duties of the Watershed Boards would be—(1), To conserve the interests of the water systems underground, and to remove causes of pollution by cesspools, dry wells, &c.; (2), To hear complaints from any part of their district, as to deficient water supply, and, if they deem proper; (3), To advertise for competing schemes for supplying the part of their district in need of water; (4), To examine, with the aid of their Commissioner, the schemes propounded, so as to determine whether all local sources have been tapped, and if satisfied with any of them, to pass it to their Commissioner, with instructions to forward it to the Local Government Board, who may, if they please, order any further inquiry; (5), To veto any scheme which does not pass the examination by themselves, in concert with their Commissioner;* (6), To enforce the due performance of the provisions of the parts of the Public Health Act, 1875,† relating to water supply and the Public Health (Water) Act, 1878; (7), To levy rates; (8), To report annually to their Commissioner, who would make general report to Local Government Board.

S.—Powers of Watershed Boards.

They should be empowered‡ to purchase lands, purchase or construct waterworks and reservoirs; to put water into them§ when made; and to distribute water within their district, &c., &c.

T.—Duties of Sub-commissioners.

Each of the three Commissioners should have a staff composed of two Sub-Commissioners, who would assist him in his duties in the Sub-Commissioners' districts, shown on the accompanying map, with such other temporary or permanent assistance as they might require.

U.—President of Local Government Board to retain present functions after establishment of Watershed Boards, &c.

Finally, at the head of all would be the President of the Local Government Board,¶ who would answer in Parliament all questions connected with water supply.**

* Royal Commission on Water Supply, 1869, Part V., Sec. IV., § 246, 248, and pp. cxxii-cxxiii. Royal San. Com., Report, p. 3, Observations, pp. 15-16. Royal Com. on Water Supply, § 263, p. cxxvii; § 264, p. cxxviii. Do., do., Part VI., § 256, p. cxxv.

† Royal Com. on Water Supply, 1869, Part VI., § 255, p. cxxv. 6th Report Rivers Pollution Commission, p. 430. Report of Select Committee on Public Health Act (1875) Amendment Bill, 1878, Part IV., § 17. p. vii. National Water Supply Congress papers, J. F. Bateman, J. W. W. Bund, E. Frankland.

* Royal Sanitary Commission 1869 report, p. 39.

† 38 & 39 Vict., c. 55, 62.

‡ 38 c., 39 Vict., c. 55, 51, 52.

§ National Water Supply Congress, Disc., De Rance, p. 8.

‖ 38 & 39 Vict., c. 55, 51, 63.

¶ Royal Sanitary Commission, 1869, Report, p. 26. Rivers Conservancy, British Association, Easton, p. 21.

** Report of Royal Sanitary Commission, 1869. Paper on Watershed Boards (Lord Robert Montagu), p. 347.

V.—As to Appointment of Commissioners.

The three Commissioners should be appointed by the Crown (and not by the Local Government Board), but they would hold permanent office. The six Sub-Commissioners should also be appointed by the Crown, with permanent office. In the Watershed Boards the elective members would hold office for three years, but would be eligible for re-election.*

W.—General View of the Advantages of the Suggested Arrangement.

The advantages of this arrangement would be that (1) the areas administered by Watershed Boards would be large enough to be properly dealt with, which the existing areas are not; (2) that the Watershed Boards would have the Commissioners and Sub-Commissioners resident in their districts, familiar with their wants, working with them, and, for this reason, having amongst them the very highest scientific attainments and knowledge (for the qualifications of a Commissioner should be a high one)† accessible, without an amount of red tape that now renders the scientific staff of the Local Government Board to a great extent useless to country districts;‡ (3) that it would be to the interest of the Commissioners to see water supply properly carried out, whereas at present nobody but the engineer who prepares the plans and carries out the work cares anything about it. (4) That the Local Government Board§ would have nothing to do with it, beyond granting provisional orders, and perhaps, in rare instances, putting their veto on some scheme. (5) The people would find out, and gladly, that they were acting for themselves, carrying out their own schemes of improvement in water supply, and without the depressing sense of the existence of a superior authority immediately above them, always ready to press them rather faster than they are inclined to move, a state of things which has produced a deadlock with the Local Government Board* (which was intended to be the mainspring of action) and local authorities. (6) That in the rare cases in which the Local Government Board may refuse a provisional order, the action is not direct, but there is the Commissioner as a cushion in between to bear the brunt,† and who, doubtless, will be well paid to bear it.‡

X.—Conclusion.§

Thus the real mainspring in the provision of knowledge by the Hydro-Geological Survey, and the independent co-operation of the Watershed Boards with their Commissioners, would, no doubt, soon produce the good result of placing the water supply of the country in a satisfactory state.‖ But there is a great deal to be done, not the smallest part of which is the education of the people themselves in sanitary subjects.¶ When will they learn that it is cheaper to pay for pure water, than for the father of a family to be killed by a fever, generated by drinking the polluted water of his own well, and, may be, leave ten or a dozen weakly children, from the same cause, dependent upon the poor-rates?

The scheme which I have the honour to suggest is the natural outcome of the progress of popular opinion during the last fifteen years; and, if there is not any original suggestion in the paper, the combination is, perhaps, new, and ought, at least, to work satisfactorily. It is not by any one great effort that the *vis inertiæ* is to be overcome, but by the constant dropping which suggests my motto, —*Gutta cavat lapidem, non vi, sed sæpe cadendo.*

* Rivers Conservancy Bill, clause 6.

† National Water Supply Congress, disc. (Dr. Syson), p. 9.

‡ National Water Supply Congress. Papers (F. R. Conder), p. 40.

§ Royal Sanitary Commission, 1869, report:—The central authority recommended (which proved to be the Local Government Board) "must not take to itself the actual work of local government—should have direction only. It must steer clear of the work on which the General Board of Health was wrecked; for so completely is self-government the habit and quality of Englishmen, that the country would resent any central authority undertaking the duties of the local executive" (pp. 35, 36).

* National Water Supply Congress, discussion, G. W. Child, p. 7.

† Report Royal Sanitary Commission, 1869, letter on Watershed Boards, Lord Robert Montague, p. 340.

‡ The Working of the Sanitary Acts in Rural Districts, W. H. Michael, Transac. Inst. Surveyors, Vol. viii., p. 375 (lines 26 to 33)

§ National Water Supply, discussion, Lucas, Clutterbuck, Chadwick, C.B., Conder (pp. 2, 3): Child (p. 4), Shelford, Bond, De Rance (p. 5; ditto papers—Bund (p. 30), Child, Clutterbuck (p. 38), Conder (p. 40), Bailey Denton (p. 44), De Rance (p. 45), Homersham (pp. 52, 53, Lucas (p. 55), Parry (57), Prestwich (pp. 62—66), Shelford (p. 66), Seymour (pp. 70—72).

‖ Royal Sanitary Commission, 1869 report, and authorities too many to enumerate.

¶ The working of the Sanitary Acts, &c. Michael. P. 376.

APPENDIX A.

Nature of Evidence.	List of Authorities.	Date.
Reports:—		
Royal Commissions	Royal Commission on Water Supply	1869
	Royal Sanitary Commission	1869
	Pollution of Rivers Commission, 6th Report	1874
	River Clyde Pollution.	
Parliamentary Committees	House of Lords:—	
	Conservancy Boards Committee	1877
	House of Commons:—	
	Thames Floods Prevention	1877
	Public Heath Act, 1875, Amendment Bill	1878
Acts of Parliament:—		
[34 & 35 Vict. c. 70]	Local Government Board Act	1871
[38 & 39 Vict. c. 55]	Public Health Act (1875)	1875
[41 & 42 Vict. c. 25]	Public Health (Water) Act	1878

Appendix A.—(*Continued.*)

Nature of Evidence.	List of Authorities.	Date.
Bills in Parliament	Rivers Conservancy Bill	1879
	County Boards Bill	1878 and 1879
Congresses	National Water Supply, Society of Arts	1878
	Rivers Conservation, British Association	1878
Transactions of Institutions :—		
Papers	"The Working of the Sanitary Acts in Rural Districts" (Trans. Inst. Surveyors, vol. VIII., p. 363.)	1876
	"County Boards" .. .. (*Ibid*, vol. x., p. 151.)	1878
Miscellaneous	Digest of the English Census of 1871, by James Lewis ..	
	Symons's Rainfall Maps, &c.	
	Geological Maps—various.	

APPENDIX B.

TABLE I.

1.—District of the Commissioners of Northern Boards.

(*a.*) *Western Sub-Commissioner's District.*

Name of Watershed.	No. on Ordnance Map.	Area (sq. miles).	Group.	No. of Watersheds.	Mean Rainfall. Mean Range.	Mean Rainfall. Inches.	Geology.
1. Several small streams ...	vi	21					
2. Line	vii	104					
3. Eden	xix	915	1	5	30 to 75	41·17	New Red Sandstone, Permian, millstone grit, carboniferous limestone, Silurian.
4. Wampool...	xiv	78					
5. Waver	xv	70					
6. Ellen	xvi	72					
7. Derwent	xviii	262					
8. Several small streams ...	xvii	11					
9. Ehen	xxv	72	2	7	30 to 75	41·17	Coal measures, millstone grit, carboniferous limestone, and a little Permian on coast.
10. Calder	xxvi	28					
11. Irt	xxvii	61					
12. Esk	xxviii	64					
13. Several small streams ...	xxxi	28					
14. Duddon	xxix	46					
15. Several small streams ...	xxxii	56					
16. Leven	xxx	202	3	7	25 to 75	41·17	The same as Group 2.
17. Kent	xxxiii	255					
18. Lune	xxxiv	418					
19. Wyre	xli	208					
20. Ribble	xlii	585					
21. Small stream	xlv	7	4	4	25 to 75	41·17	New Red Sandstone, coal measures, millstone grit, &c.
22. Douglas	xlvi	168					
23. Several small streams ...	xliv	55					
24. Alt	xlvii	126					
25. Mersey	xlviii	885	5	4	25 to 75	38·74	New Red Sandstone, Permian, coal measures, millstone grit, carboniferous limestone, and Silurian.
26. Weaver	lxxi	711					
27. Dee	lxx	813					
28. Clwyd	lxix	319					
29. Several small streams ...	lxviii	39					
30. Conwy	lxvii	222					
31. Several small streams ...	lxi	78					
32. Seiont, Gorfai, &c. ...	lxii	143					
33. Soch	lxiii	33					
34. Erch	lxiv	55					
35. Dwyfach and Dwyfawr ...	lxv	48					
36. Prysor	lxvi	141					
37. Artro	lxxv	45					
38. Small streams	lxxvi	3					
39. Mawddach	lxxvii	151					
	Mainland	7,598	6	17	40 to 75	...	Cambrian and Silurian, with carboniferous limestone in Anglesey.
Anglesey.							
40. Braint	lx	53					
41. Cefni	lix	41					
42. Several small streams ...	lvii	69					
43. Alaw	lvi	58					
44. Several small streams ...	lviii	47					
	Anglesey	268					
Total, with Anglesey ...	...	7,866		44			

Appendix B.—(*Continued.*)

(*b.*) *Eastern Sub-Commissioner's District.*

Name of Watershed.	No. on Ordnance Map.	Area (sq. miles).	Group.	No. of Watersheds.	Mean Rainfall. Mean Range.	Mean Rainfall. Inches.	Geology.
1. Tweed (part of)	i	37					
2. Till	ii	231					
3. Several small streams ...	iii	129					
4. Aln	iv	104					
5. Coquet	v	240	1	10	25 to 50	41·17	Coal measures, millstone grit, and carboniferous limestone, with some intrusive or trap rocks.
6. Several small streams ...	x	18					
7. Several small streams ...	xi	37					
8. Wansbeck	ix	126					
9. Blyth	xii	131					
10. Several small streams ...	xiii	31					
11. Tyne	viii	1,130	2	1	25 to 50	41·17	Coal measures, millstone grit, and carboniferous limestone.
12. Wear	xx	456	3	1	25 to 50	41·17	Permian, coal measures, millstone grit, and carboniferous limestone.
13. Several small streams ...	xxi	77	4	2	25 to 50	41·17	Oolite, Lias, New Red, coal measures, millstone grit, carboniferous limestone.
14. Tees	xxii	708					
15. Several small streams ...	xxiii	100	5	2	25 to 50	41·17	Oolite and Lias.
16. Esk	xxiv	147					
17. Ouse	xxxv	1,842				30·88	Oolite, Lias, New Red Sandstone, Permian, coal measures, millstone grit, and carboniferous limestone.
18. Aire and Calder	xliii	815	6	3	25 to 50	30·88	New Red, Permian, millstone grit, and carboniferous limestone.
19. Don	xlix	682					
20. Derwent	xxxvi	794	7	1½	25 to 50	30·88	Chalk, Oolite, Lias, New Red Sandstone.
21. Several small streams ...	xxxvii	157					
22. Hull	xxxviii	361					
23. Foulness	xxxix	133	8	3½	25 to 50	30·88	Post tertiary, chalk, Oolite, Lias, and New Red Sandstone.
24. Several small streams ...	xl	206					
Eastern Sub-Commissioner's District...		8,695		24			
44. Western Sub-Commissioner's Districts		7,866					
68. Total area under Commissioner of Northern Boards		16,561					

District of the Commissioner of Midland Boards.

Western Sub-Commissioner's District.

Name of Watershed.	No. on Ordnance Map.	Area (sq. miles).	Group.	No. of Watersheds.	Mean Range.	Inches.	Geology.
1. Dysynni	lxxviii	64					
2. Afon Dyfi	lxxix	217					
3. Lery	lxxx	34					
4. Stream	lxxxi	24					
5. Rheidol	lxxxii	70					
6. Ystwyth	xcviii	75					
7. Wyrai	xcix	23	1	12	40 to 75	...	Silurian.
8. Arth	c	31					
9. Aeron	ci	52					
10. Several small streams ...	cii	48					
11. Teifi	ciii	386					
12. Nevern, Gwaen, &c. ...	civ	94					
13. St. Bride's Bay	cv	65					
14. E. and W. Cleddau ...	cvi	212					
15. Pembroke	cvii	114					
16. Several small streams ...	cviii	61					
17. Taf	cix	183					
18. Towy	cx	514					
19. Gwendraeth-fach ... / Gwendraeth-fawr ...	cxii	73					
20. Llwchwr	cxiii	156	2	14	40 to 75	46·15	Coal measures, millstone grit, carboniferous limestone, Old Red Sandstone, Silurian, with a little Oolite, and New Red Sandstone (cxx and cxviii).
21. Small stream	cxiv	66					
22. Tawe	cxv	106					
23. Neath	cxvi	118					
24. Afon	cxvii	87					
25. Ogmore	cxviii	114					
26. Several small streams ...	cxx	67					
27. Ely	cxxi	81					
28. Taff	cxix	198					
29. Rumney	cxxii	94					
30. Ebwy	cxxiii	94	3	7	25 to 75	...	Oolite, New Red Sandstone, coal measures, millstone grit, carboniferous limestone, Old Red Sandstone, and Silurian.
31. Usk	cxxiv	540					
32. Several small streams ...	cxxv	55					
33. Wye	cxi	1,609					
34. Severn	lxxxiii	4,350	4	1	25 to 75	...	Oolite, Lias, New Red Sandstone, Permian, coal measures, millstone grit, carboniferous limestone, Old Red Sandstone, and Silurian.
		10,075		34			

Appendix B.—(*Continued.*)

Eastern Sub-Commissioner's District.

Name of Watershed.	No. on Ordnance Map.	Area (sq. miles).	Group.	No. of Watersheds.	Mean Rainfall. Mean Range.	Mean Rainfall. Inches.	Geology.
1. Trent	lxxii	4,052	1	1	25 to 50	30·88	Oolite, Lias, New Red Sandstone, Permian, coal measures, millstone grit. carboniferous limestone.
2. Ancholme	l	244					
3. Several small streams ...	li	122					
4. Several small streams ...	lii	39					
5. Lud	liii	139	2	6	25 to 50	30·88	Oolite and chalk (Ancholme) chalk, and post tertiary.
6. Withern Eau	liv	189					
7. Steeping	lv	101					
8. Witham	lxxiii	1,079	3	1	25 to 50	29·11	Oolite, chalk, and fen.
9. Welland	lxxiv	760	4	2	25 to 50	29·11	Oolite and fen.
10. Nen	lxxxiv	1,077					
11. Ouse	lxxxv	2,607					
12. Wissey	lxxxviii	243	5	4	25 to 50	29·11	Chalk gault, lower greensand, Oolite, Lias, and fen.
13. Nar, or Setchy	lxxxvii	131					
14. (lxxxvi) part of	lxxxvi	abt. 93					
		10,876		14			
34. Western Sub-Commissioner ...		16,075					
48. Total area under Commissioner of Midland Boards		20,951					

District of the Commissioner of Southern Boards.

Western Sub-Commissioner's District.

Name of Watershed.	No. on Ordnance Map.	Area (sq. miles).	Group.	No. of Watersheds.	Mean Range.	Inches.	Geology.
1. Avon	cxxvii	891	1	2	25 to 40	...	Oolite, Lias, carboniferous limestone, and New Red Sandstone.
2. Yeo	cxxvi	106					
3. Axe	cxlv	101					
4. Brue	cxlvi	197					
5. Several small streams ...	cxlvii	80					
6. Perret	cxlviii	562	2	7	25 to 40	...	Oolite, Lias, New Red Sandstone, and Devonian.
7. Small stream	cxliii	82					
8. Small stream	cxlii	24					
9. Small stream	cxli	29					
10. East Lynn	cxl	41					
11. Small streams	cxxxvii	47					
12. Jaw	cxxxix	455	3	5	40 to 75	...	New Red, carboniferous limestone, Devonian, granite (Dartmoor).
13. Torridge	cxxxviii	336					
14. [Bideford Bay]	clxxxv	10					
15. [Bude Bay]	clxxxvi	108					
16. [Pentire Point]	clxxxviii	8					
17. Alan or Camel	clxxxix	149					
18. Several small streams ...	cciii	154					
19. Small streams	ccix	43	4	7	40 to 50	...	Carboniferous and Devonian, with some granite.
20. St. Ives	Not numbered						
21. Small streams	ccvii	47					
22. Several small streams ...	ccviii	40					
23. Several small streams ...	ccx	29					
24. Small streams	ccxv	33					
25. Small streams	ccxiv	10					
26. Small streams	ccxiii	33					
27. [Falmouth]	ccxii	12					
28. Small stream	ccxi	40	5	11	40 to 50	...	Same as Group 4, without carboniferous.
29. [Truro]	cciv	66					
30. Fal	ccv	50					
31. Several small streams ...	ccvi	80					
32. Fowey	cxc	120					
33. Several small streams ...	cxci	71					
34. Lynher	cxcii	100					
35. Tamar	clxxxvii	385					
36. Tavy and Wallcombe ...	cxciii	85					
37. Plymouth Leat	cxciv	23					
38. Plym	cxcv	59	6	9	40 to 75	...	Carboniferous, Devonian, and granite (Dartmoor).
39. Yealme	cxcvi	36					
40. Erme	cxcvii	43					
41. Aune	cxcviii	54					
42. [Start Point]	ccii	73					
43. Dart	cxcix	200					
44. Teign	cc	203	7	4	40 to 75	33·73	New Red, Devonian, carboniferous, and granite.
45. Stream	cci	11					
46. Ex	cxliv	584					

Appendix B.—*Western Sub-Commissioner's District.*—(*Continued.*)

Name of Watershed.	No. on Ordnance Map.	Area (sq. miles).	Group.	No. of Watersheds.	Mean Rainfall. Mean Range.	Mean Rainfall. Inches.	Geology.
47. Otter	cxlix	82					
48. Stream	cl	21					
49. Axe	cli	165					
50. Char	clii	39	8	7	30 to 40	...	Chalk, Oolite, Lias.
51. Brit	cliii	52					
52. Bredy	cliv	21					
53. [Weymouth]	clv	87					
54. Frome	clvi	187					
55. Trent or Piddle	clvii	119	9	4	30 to 40	30·16	Tertiary, chalk, Oolite.
56. Stour	clviii	459					
57. Avon	clix	673					
58. Lymington	clxi	91					
59. Beaulieu	clxii	52					
60. Test	clx	477					
61. Itchen	clxiii	231					
62. Hamble	clxiv	35					
63. ,, ...	clxv	85					
64. ,, ...	clxxi	235					
65. ,, ...	clxxii	26	10	13	30 to 40	30·16	Tertiary and chalk, with a little upper greensand; gault and lower greensand.
Isle of Wight.							
66. [Solent]	clxvi	11					
67. [Solent]	clxvii	25					
68. Medina	clxviii	28					Tertiary, chalk, upper greensand, gault, lower greensand, and Wealden.
69. [Spithead]	clxix	19					
70. South Coast	clxx	51					
Area of Isle of Wight		134	70				
Mainland		9,047					
Total Area Western Sub-Commissioner's District...		9,181					

Eastern Sub-Commissioner's District.

Name of Watershed.	No. on Ordnance Map.	Area (sq. miles).	Group.	No. of Watersheds.	Mean Range.	Inches.	Geology.
1. Arun	clxxiii	370					
2. [Worthing]	clxxiv	35					
3. Adur	clxxv	160					
4. [Brighton]	clxxvi	56					
5. Ouse	clxxvii	205	1	9	25 to 40	...	Tertiary chalk, upper greensand, gault, lower greensand, weald clay, and lower Wealden sands.
6. Cuckmere	clxxviii	75					
7. Oldhaven	clxxix	121					
8. Rother	clxxx	312					
9. [Hythe]	clxxxiv	88					
10. Stour	clxxxiii	373					
11. Several small streams ...	clxxxii	157	2	3	22 to 31	...	Tertiary chalk and Wealden.
12. Medway	clxxxi	680					
13. Cray and Darent	cxxxvi	314					
14. Thames and Lea	cxxviii	4613	3	3	22 to 31	24·56	Tertiary chalk, upper greensand, gault, lower greensand, Oolite, and Lias.
15. Roding, &c.	cxxxiv	317					
16. Crouch	cxxxv	181					
17. Blackwater	cxxxi	434					
18. Coast	cxxxii	24					
19. Colne	cxxx	192					
20. Coast	cxxxiii	53					
21. Stour	cxxix	407	4	12	22 to 31	...	Post tertiary, tertiary, and chalk.
22. Gipping or Orwell... ...	xcvii	171					
23. Deben	xcvi	153					
24. Coast	xcv	32					
25. Ore or Alde	xciv	109					
26. Minsmere	xciii	34					
27. Blyth	xcii	79					
28. Coast (Lowestoft)... ...	xci	53					
29. Waverley and Yare ...	xc	880	5	4	22 to 31	...	Post tertiary and chalk.
30. Bure	lxxxix	348					
31. Glaven (part of)	lxxxvi	200					
		11,226		31			
Western Sub-Commissioner's district ...		9,181					
Total under Commissioners of Southern Boards		20,407					

APPENDIX B.—(*Continued.*)

TABLE II.

COMMISSIONER OF NORTHERN BOARDS.

Counties.	Population.	
Western Sub-Commissioner :—		
Cumberland (part of)	214,573	
Westmoreland	65,010	
Lancashire	2,819,495	
Yorkshire (part of)	24,934	
Derbyshire (part of)	24,391	
Cheshire..	561,201	
Flint	76,312	
Denbigh	105,102	
Carnarvon	106,121	
Anglesea	51,040	
Merioneth (part of)	41,442	
		4,089,621
Eastern Sub-Commissioner :—		
Northumberland	386,646	
Cumberland (part of)	5,680	
Durham..	685,089	
Yorkshire (part of)	2,402,512	
Derbyshire (part of)	67,911	
		3,547,838
Total under Northern Commissioner..		7,637,459

COMMISSIONER OF MIDLAND BOARDS.

Counties.	Population.	
Western Sub-Commissioner :—		
Merioneth (part of)	5,156	
Montgomery	67,623	
Cardigan	73,441	
Pembroke	91,998	
Caermarthen	115,710	
Glamorgan	397,859	
Brecknock	59,901	
Radnor	25,430	
Shropshire	248,111	
Hereford	125,370	
Monmouth	195,448	
Gloucester (part of)	255,264	
Worcester (part of)	231,376	
Stafford (part of)	90,298	
Warwick (part of)	211,339	
Leicester (part of)	35,317	
Northampton (part of) ..	4,709	
		2,234,350

Commissioner of Midland Boards.—(Continued.)

Counties.	Population.	
Eastern Sub-Commissioner :—		
Stafford (part of)	768,028	
Worcester (part of)	107,461	
Derby (part of)..	287,092	
Warwick (part of)	422,850	
Nottingham	319,758	
Yorkshire (part of)	8,909	
Lincoln	436,599	
Leicester (part of)	233,994	
Rutland	22,037	
Northampton (part of) ..	230,877	
Oxford (part of)	1,140	
Buckingham (part of).. ..	64,648	
Bedford (part of)	114,240	
Huntingdon	63,708	
Hertford (part of)	32,635	
Cambridge	186,906	
Norfolk (part of)	91,092	
Suffolk (part of)	44,575	
Essex (part of)	16,152	
		3,452,737
Total under Midland Commissioner ..		5,687,087

COMMISSIONER OF SOUTHERN BOARDS.

Counties.	Population.	
Western Sub-Commissioner :—		
Cornwall	362,343	
Devonshire	601,374	
Somersetshire	463,483	
Gloucester (part of)	236,513	
Dorsetshire	195,537	
Wiltshire (part of)	197,419	
Hants (part of)..	478,769	
Sussex (part of)	33,358	
		2,568,796
Eastern Sub-Commissioner :—		
Wiltshire (part of)	59,758	
Gloucester (part of)	42,863	
Oxfordshire part of)	176,835	
Northampton (part of) ..	8,305	
Berkshire	196,475	
Hants (part of)..	65,915	
Sussex (part of)	384,098	
Surrey	1,091,635	
Kent	848,294	
Buckingham (part of).. ..	111,231	
Hertford (part of)	159,591	
Middlesex	2,539,765	
Essex (part of)	450,284	
Suffolk (part of)	304,294	
Norfolk (part of)	347,564	
Bedford (part of)	32,017	
		6,818,924
Total under Southern Commissioner ..		9,387,720

Appendix B.—(*Continued.*)

TABLE III.—SUMMARY OF TABLES I. AND II.

	Area Sqre. Miles.	Population.	Mean Rain. (Range of Mean.)	No. of Watershed Basins.	Principal Water-bearing Formations, Surface and Subterranean.
Commissioner of Northern Boards.			Inches.		
Western Sub-Commissioner	7,866	4,089,621	25 to 75	44	Silurian, carboniferous, and New Red Sandstone.
Eastern Do.	8,695	3,547,838	25 to 50	24	Carboniferous, New Red, Oolite, and chalk.
Total	16,561	7,637,459		68	
Commissioner of Midland Boards.					
Western Sub-Commissioner	10,075	2,234,350	25 to 75	34	Silurian, Old Red Sandstone, carboniferous, and New Red.
Eastern Do.	10,876	3,452,737	25 to 50	14†	New Red, Oolite, lower greensand, chalk.
Total	20,951	5,687,087		48	
Commissioner of Southern Boards.					
Western Sub-Commissioner	9,181	2,568,796	25 to 75	70*	Devonian, carboniferous, New Red, Oolite, and chalk,
Eastern Do.	11,226	6,818,924	22 to 40	31†	Lower Wealden sands, lower greensand, chalk, tertiary.
Total	20,407	9,387,720		101	

* With "St. Ives," not numbered on Ordnance Map. † With part of No. LXXXVI.

MISCELLANEOUS.

INDIAN ART.

The following address has been presented to Dr. Birdwood, in acknowledgment of his report on Indian Art at the Paris Exhibition:—

To George C. M. Birdwood, Esq., M.D., C.S.I., &c., &c.

Dear Sir,—We, the undersigned, wish to express the thanks we owe you for the manner in which you have performed an important duty, in your report on the articles of Indian manufacture exhibited in Paris last year. In common with all who have given any attention to the subject, we have seen and lamented the rapid deterioration that has of late befallen the great historical arts of India. The independent and courageous criticism contained in your handbook, founded on close observation and long experience, has shown us the causes that have been at work in bringing about this deterioration, and has given us hope that something may yet be done to stay its further progress.

We do not doubt that all men of culture will agree with us in thinking that the welfare of the arts in question is important both to India and to Europe, and that the loss of them would be a serious blow to civilisation and an injury to the pleasure and dignity of life; and if this importance be at once admitted, together with the danger to them that comes of the manner in which they are now being dealt with by Europeans that are brought into contact with the Asiatic workmen, we cannot conceive that any thoughtful person will deny the responsibility of England in the matter, or the duty which a great country owes to the Arts, of exercising foresight and patience, lest, for an apparent commercial gain, she, and the world in general, should lose industries which have for ages made India famous, industries whose educational influence on the arts of the West is so universally acknowledged by all the students of art and history.

At a time when these productions are getting to be daily more and more valued in Europe, their sources are being dried up in Asia, and goods which ought to be common in the market at reasonable prices are now becoming rare treasures for museums or the cabinets of rich men. This result seems to us the reverse of what commerce ought to aim at, and we cannot help thinking that, when the producers and the public wake up to a knowledge of the facts in the case, they will be eager to restore these industries to their due position. We think they will have a good chance of success if it be not then too late, and if no artificial obstacles be thrown in their way.

We therefore think that your remarks on these manufactures were both necessary and timely, and will be most useful in promoting a better understanding of the only conditions under which the so-much-admired art of the East can flourish, or, in the long run, exist; and we beg once more to tender you our hearty thanks, in the full belief that in so doing we express the feelings of all lovers of art who have read your excellent report.

This letter was signed by the following gentlemen:—George Aitcheson, Sir Rutherford Alcock, K.C.B., Thomas Armstrong, C. Purdon Clarke, M. E. Grant-Duff, M.P., Prof. W. Stanley Jevons, F.R.S., Edward Burne Jones, Sir Coutts Lindsay, Bart., James D. Linton, George J. S. Lock, Prof. Nevil S. Maskelyne, F.R.S., John E. Millais, R.A., William Morris, Robert Phillips, Richard Redgrave, R.A., Vincent Robinson, William Spottiswoode, P.R.S., R. Norman Shaw, R.A., W. T. Thornton, C.B., Horace Walpole, Thomas Woolner, R.A., Edwin Arnold, G. P. Boyce, T. Chenery, Walter Crane, Frank Dillon, Henry Doulton, Col. Arthur Ellis, C.S.I., Barrow H. Ellis, F. Garrard, Carl Haag, J. A. Heaton, W. Hertz, George Howard, Sir Frederick Leighton, P.R.A., A. Morrison, C. R. Markham, C.B., F.R.S., Sir Lewis Pelly, K.C.B., Val. Prinsep, A.R.A., Sir Henry Rawlinson, K.C.B., Philip Webb, Col. H. Yule, C.B.

Dr. Birdwood's reply is as follows:—

India-office, June 1, 1879.

Gentlemen,—In acknowledging your letter of May 1, 1879, I must begin by frankly confessing to a feel-

ing of intense personal pleasure. Not less sincere is my satisfaction in receiving so weighty a testimony to the excellence of the historical handicrafts and hereditary craft-masters of India. Your approbation will do more even than last year's Paris Exhibition to quicken the growing popular interest in Indian art, and in the self-contained and self-supporting Indian communal life, of which the arts of that country are the bright emanation. The unity in variety of Indian, as of all Eastern life, must never be overlooked by those who would understand the traditional arts of India and the East. It has a vital lesson for us, among whom, owing to our system of land tenure, those political revolutions, which in the East rarely affect the democratic organisation of society, have so often destroyed the continuity of popular progress, to the manifest injury of the indigenous domestic arts and of the higher forms of art, such as painting and sculpture, for which the people of the West have a far greater natural ability than those of the East. Art in England has therefore rather expressed sectarian views than the catholic sentiments of a people at complete unity with themselves; and this is why it has hitherto failed, both in homely use and epic grandeur. It is only in times of its decay that men begin to talk of art as being its own end and aim. In reality art is the highest expression of the whole moral and material condition of a people, and their ever strengthening incentive to a higher life. To impart this incentive has always been the purpose of art wherever it has sprung from the life of a people, and where it does not serve this end, where, through social disorganisation, it is no longer rooted in national life, it fails in inborn vigour and originality, and ceases to exercise any elevating influence on national character.

The arts of India are indissolubly bound up with the popular institutions of the country, and, however much the Hindu may have erred from the right way, and obscured the light that is in him, he yet, as regards all the thoughts and intents of his heart, lives in the unseen world of man's spiritual consciousness, by which he is influenced in every act of his life, and in whatsoever he does to adorn life; and art, the preservative of all arts, is true to itself, and vindicates its participation in divineness only when it is inspired by the highest ideals of a people gathered together in natural and co-ordinated unity, as in the co-operative village communities of India.

In estimating the disturbing effect of European influences on the arts of India we must avoid too exclusive and too indiscriminate blame of schools of art. The influence of Europe on the East is inevitable, and the presence in India of cultivated Englishmen at the head of schools or art cannot fail in the end to correct the degrading effects of the necessary strain of European commerce on the village and sumptuary arts of India. After all, the chief offenders against art in India are the official departments engaged in the manufacture of jail carpets and the construction of public buildings, and it is particularly through the neglect of native architecture, and the propagation of a bastard English style, blindly followed by the people themselves, that the Government threatens the slow destruction of the historical handicrafts of India. Art never long survives among a people who neglect architecture, the chief of the arts. All the minor arts in England suffered during the period of the decline of our national building style, and our painting and sculpture still suffer, as is shown in a prevailing anecdotal character, from their long disassociation with architecture. But in many parts of India, such as Rajputana and Kattyawar, a spontaneous native architecture survives. The late Alexander Kinloch Forbes, author of "Ras Mala," was always seeking to obtain the employment of the native workmasters (maestries) of Kattyawar on public buildings of their own designing, and it is not yet too late for the Government, by the encouragement of native hereditary architects, not only to arrest the decadence of the arts of India, but to promote their revival. Schools of art might become effective agents in this renaissance, only it is absolutely essential that their work should begin, where that of the native draughtsman always begins, with the study of architecture. There is absolutely nothing in what has been advanced to justify the charge sometimes made of a desire to orientalise the decorative arts of other countries. But every European, artificer and artist alike, might well take the handicraftsman of India for an example in the patience, perseverance, and thoroughness which are the ground of their excellency, and by which the inspirations of art are wrought into reality and life. The legerdemain which some would fain substitute for patient labour in the arts, not only destroys all mastery in their methods, but at last dissipates the very sense of artistic imagery and invention. Labour is the probation of perfection. The innumerable ingenuities and subtle incommunicable graces of the arts, can be obtained through labour alone; and their end and aim must, as is taught by all Eastern art,

"By Nyle, or Gange, or Tygre, or Euphrate."

be steadfastly set on the glory and enjoyment of the Most Highest, in whom is the Perfect Mastery and the Sum of Perfection.—I have, &c.,

George Birdwood.

To William Morris, Esq., and others.

HOLLWAY'S PROCESS.

Mr. John Hollway has forwarded for publication in the *Journal*, the following account of his new application of rapid oxidation by which sulphides are utilised as fuel. It is published now, inasmuch as it seems probable many of the members may be glad of a summarised account of the process, who might not have had time or inclination to read the longer and more technical account given in Mr. Hollway's paper read before the Society, February 12th, 1879.

This process has for its object the utilisation of the heat generated by the rapid oxidation of certain mineral substances, which have not hitherto been used as sources of heat for smelting operations. The heat thus obtained is employed in the reduction of the furnace charge, which may be composed partly of sulphides and partly of siliceous ores. A current of air is forced through molten sulphides, by which means they are very rapidly oxidised. Great heat is thus developed, rendering the process of smelting a self-supporting operation; therefore no extraneous fuel is required, excepting that employed in raising steam for the blowing engines; where however water power is available, steam can be dispensed with, in which case all the carbonaceous fuel necessary for the operation, is a little coke to start the furnaces, which stands in the same relative position to the ores, as wood does to coal in the lighting of an ordinary fire.

It is well-known that pyritous minerals are readily combustible, but the best means of utilising the heat-producing property of metallic sulphides, is not so apparent as would at first sight appear. Of these sulphides, only iron pyrites is sufficiently combustible at a low temperature to burn in the open air, the mass being raised to the temperature at which the oxidation takes place solely by the union of sulphur and iron with atmospheric oxygen. In Spain there are numerous deposits of poor cupreous pyrites, and the Rio Tinto and Tharsis Companies annually treat, at their mines, about one million tons for the extraction of copper only, which does not average 2 per cent. The process employed consists essentially in roasting the pyrites in heaps in the open air, dissolving out the copper from the roasted material, and precipitating it from the solution by means of iron. These operations extend over several

months, any gold or silver contained in the ore is lost, and the iron and sulphur are also wasted. The sulphur passes into the air as an obnoxious and annoying gas, desolating the country for miles around the works.

From the earliest ages, carbon has been considered a necessity in all metallurgical operations. The first reduction of metals by means of carbon forms a connecting link between the age of stone and the commencement of civilised art. It is well known that carbon burns at widely varying temperatures, as, for example, in our bodies, in a common coal fire, or in a furnace. A great deal of thought has been devoted to the subject of economising carbonaceous fuel, and great advances have been made in this direction; yet the expenditure of coal or coke necessary, say to melt a given quantity of metal still far exceeds the theoretical limit. The main causes of this discrepancy may be accounted for as follows:—

1st. Only part of the oxygen of the air passing into a furnace, acts on the material to be burnt.

2nd. The oxygen is not brought in contact with the combustible matter with sufficient rapidity, to obtain the necessary temperature for the operation.

3rd. Gases pass off hot and unburnt. These are now, however, frequently utilised.

There is one metallurgical operation in which the first two sources of loss are avoided, viz., "Bessemer's," where, by blowing air through molten crude iron, a very high temperature is attained by the combustion of small quantities of carbon and silicon contained in the crude iron; this is, however, not the case in the process of puddling, where the oxidation is spread over a considerable period of time, although the same constituents are frequently burnt in similar proportions. But even in the Bessemer process the carbon is only half burned, and a large amount of heat escapes with the carbonic oxide and nitrogen.

When, however, thin streams of air are forced through molten sulphide of iron lying on a tuyère hearth, a high temperature is produced by the perfect combustion which ensues in the midst of the sulphides, and no unburnt gases, excepting nitrogen, and sulphur vapour, escape from the surface of the molten mass. The hot nitrogen and sulphurous acid may be caused to act upon iron pyrites and other mineral matter, and when pyrites is thus heated, an atom of sulphur held in feeble combination is in great part expelled, and thus is obtained molten protosulphide of iron, which is subsequently burnt by the oxygen of the air driven in at the lower part of the furnace, thereby producing the heat necessary for continuing the operation. The process may be defined as a system of fractional oxidation, in which the numerous constituents of a complex furnace charge can be separated from each other and concentrated in different parts of the apparatus, the heat necessary for the operation being obtained by the combustion of a portion of the less valuable constituents.

The principal ores of all our ordinary heavy metals, except manganese and tin, are sulphides. Iron, although largely occurring in an oxidised form, is abundantly found in combination with sulphur; and bi-sulphide of iron, or iron pyrites, is an example of sulphurous and combustible minerals. Associated with iron and sulphur in iron pyrites are invariably found small quantities of other metals, notably cobalt, nickel, copper, silver, gold, lead, zinc, and arsenic. Of these, zinc, is almost as combustible as iron itself, while lead and arsenic readily volatilise as sulphides, and cobalt, nickel, and copper are distinctly less readily oxidisable than iron, while silver and gold do not oxidise under these conditions; hence, in supplying air to such material, the iron is the first of the elements to suffer oxidation, so that if the oxidation be arrested before the whole of the iron has been burnt, the cobalt, nickel, copper, silver, and gold present, will be found in the unburnt portion. This principle finds a parallel in the Bessemer process of treating pig-iron for the manufacture of steel, where a current of air is caused to bubble up through a bath of molten crude iron, the silicon is first oxidised, and is closely followed and to a great extent accompanied by the carbon, and no large amount of iron suffers oxidation, until the whole of the silicon and carbon have been burnt out of the molten material.

The experiments made at Messrs. Cammell's works, at Penistone, in a Bessemer converter, have proved that by blowing air through molten sulphide of iron, the iron and a portion of the sulphur are oxidised, and if the oxidation is arrested before the combustion of the iron is complete, a heavy matt or regulus is obtained, which contains but a small proporton of the iron of the ore, but practically the whole or the greater part of the copper and other less oxidisable metals. In one of these experiments the molten sulphides were run into the converter from a cupola, in which they had been previously melted, and the temperature was kept up until the operation was discontinued, viz., for a period of ten hours, without the use of any carbonaceous fuel, the heat being entirely derived from the oxidation of the iron and a portion of the sulphur of the lumps of pyrites, which were continuously thrown into the mouth of the converter. A Bessemer converter being unsuited for the collection of the gaseous products, the later experiments have been made in a series of cupola furnaces belonging to Messrs. John Brown and Company, Limited. These experiments have proved the possibility of obtaining a valuable regulus, a slag nearly free from copper, and a considerable quantity of crude sulphur. M. Pourcel, the well-known chemist of the Terrenoire Company, has also made some very interesting experiments, having treated by this method a cupriferous sulphide of antimony containing lead and zinc, using heavy spar and silica as fluxes; he obtained a regulus containing the whole of the copper in the form of sulphide, a slag of light specific gravity, and the lead, zinc, and antimony as two separate sublimates which were condensed in different parts of the apparatus, owing to the superior volatility of sulphide of lead over the oxides of antimony and zinc. In the experiments at Penistone and at Sheffield a cold blast of air was employed, and the gases which passed from the converter or furnace into the open air, carried away with them a large amount of heat. In practice, however, it would be economical to employ a hot blast, which could be heated by the waste heat from the escaping gases. It is remarkable that the least valuable metals, viz., iron and zinc, generate by their combustion the largest quantities of heat.

The process may be employed for the reduction of even the more volatile metals, for example, Mr. A. H. Allen, of Sheffield, has thus obtained metallic antimony simply by the oxidation of sulphide of antimony. It is well known that sulphide of lead reacts upon oxide of lead with the production of metallic lead and sulphurous acid. If, therefore, a limited amount of air is blown into molten sulphide of lead, the oxide thus formed in the lower part of the furnace will, in passing upward, come in contact with the hot sulphide of lead, and metallic lead will result with the evolution of sulphurous acid. The furnace having a quiescent hearth below the tuyères, the metallic lead will collect there, and can be from time to time withdrawn. A limited amount of air must be employed, because if it is driven in too quickly, the sulphide of lead will rapidly distil off. In thus treating argentiferous lead ores, the silver (and gold if present) would be found with the first metallic lead reduced. When thus treating galena the furnace should have a basic lining.

The process is peculiarly suitable:—

1st. For the treatment of metalliferous substances which cannot be advantageously treated by other processes. For the extraction of sulphur by distillation, and simultaneously for the concentration and separation of cobalt, nickel, copper, silver and gold from minerals in the form of metallic regulus; while lead, zinc, antimony, arsenic, &c., accrue in the sublimates.

2nd. For the treatment of complex ores, for example —Grey antimonial copper ores, such as those experimented on by M. Pourcel. Ores similar to those worked at the well-known Bottino Mines, Seravezza, in the Italian Apennines, which contain thirteen or fourteen heavy metals, including silver and lead, for which latter alone they have been worked for centuries. The blende of lead mines, in Derbyshire termed "muck," usually thrown away by the miners, because the large quantity of lead with which it is associated renders the zinc obtained from it worthless.

3rd. For the treatment of auriferous and argentiferous pyrites. It is well-known that in practice it is not possible to obtain the whole of the gold from pyrites by amalgamation with quicksilver, because the presence of sulphur and arsenic sickens and flours the mercury, whereas by fusion the whole of the silver and gold present is obtained.

4th. For the treatment of pyrites containing even only small percentages of cobalt, nickel, and copper, which are thus concentrated into a rich regulus, whereas this result is now only obtained by very tedious processes of alternate roasting and reduction. Such ores containing 10 per cent. and even 12 per cent. of copper exist in South America and many other parts of the world, but are not at present capable of economic treatment, owing to the difficulty of obtaining a sufficient supply of cheap fuel. The process can also be advantageously applied to the treatment of richer ores of copper such as are at present smelted at Swansea.

5th. For the treatment of poor lead ores. If such ores are added to a furnace charge of cupreous pyrites, the silica they contain will be utilised and combine with the resulting oxide of iron to form slag, the galena will be volatilised and be recovered as a sublimate, while any silver present will enrich the regulus. At present, by a costly process of crushing and washing these ores, the galena is concentrated, although a large proportion is left with the *débris*, and passes with the water into the streams, rendering the existence of fish in such waters impossible. The water power now used for washing the ore could, in many cases, be employed for producing the blast.

When thus treating cupriferous iron pyrites, four products are obtained:—

1st. A matt or regulus containing from 30 to 50 per cent. of copper, any traces of cobalt, nickel, silver or gold the ore may contain, the rest of it being iron and sulphur; it has a specific gravity of $4\frac{1}{2}$ to 5.

2nd. A slag consisting of silicate of iron from the resulting oxide of iron combined with the siliceous matters contained in the ore and the fluxes added.

3rd. Sublimed sulphur, more or less mixed with volatile compounds of lead, zinc, and arsenic.

4th. Sulphurous gases, consisting mainly of sulphurous acid and nitrogen.

The regulus closely resembles, and will replace, the coarse metal of the Swansea copper process, which is now only obtained at considerable cost of labour, time, and carbonaceous fuel. When, however, sulphides of iron and copper present in the bath are treated continuously by a blast of air a point is at length arrived at when the whole of the iron is oxidised, and the regulus in the bath consists of sub-sulphide of copper. If, now, a limited supply of air is introduced, the copper is reduced to the metallic state with the evolution of sulphurous acid.

The slag obtained in the Penistone experiments was essentially silicate of iron, containing about 50 per cent. of iron and 29 per cent. of silica. It had a density of about 3·8 to 4, and was in composition somewhat allied to the copper-smelters' ore furnace slag and to the tap-cinder of the iron-puddler. By the addition of calcareous materials, the specific gravity of the slag is so reduced as to cause it to separate readily from the regulus which collects below it. In one of the later experiments, when lime was used, the proportion of copper lost in the slag was very small. This is, of course, a most important point, for when dealing with ores containing but little copper, the presence of even a small percentage in the slag means the loss of a considerable proportion of the copper present. These slags can be utilised for the manufacture of steel, being practically siliceous iron ores free from phosphorus, and their reduction in a blast furnace can be profitably effected, as the proportion of iron present is high as compared with the weight of the material; indeed, it may be possible to reduce them while in a molten state.

By re-subliming the crude sulphur, it can be freed from all impurites except arsenic, and at the works of Messrs. John Hutchinson and Co., Widnes, this is eliminated by means of polysulphide of calcium.

As a certain proportion of the sulphur of the minerals suffers combustion, the resulting sulphurous gases contain from 14 to 15 per cent. of sulphurous acid, and hence the proportion of sulphurous acid to nitrogen is nearly identical with that of the gases produced by roasting pyrites in the kilns employed by vitriol manufacturers, and can, therefore, be used with equal advantage for the production of vitriol in leaden chambers. This appears to be the simplest solution of the great problem how to smelt copper without causing a nuisance to the surrounding neighbourhood, although a similar result might be obtained by collecting and liquifying the sulphurous acid.

The more incombustible materials it is found practicable to employ without too great a loss of temperature, the wider will become the application for the process; for there are many ores, including silicates and carbonates, containing metals in the form of oxides, which might be conveniently smelted by mixing them with a sufficient proportion of pyritous ores to effect their reduction; in fact, one of the chief practical questions connected with this process is how far it may be trusted to effect the smelting of ores or furnace charges containing comparatively moderate proportions of sulphides. It is evident that it will almost entirely obviate the necessity for using carbonaceous fuel, at least as far as the production of a regulus is concerned, and consequently the localities in which smelting operations may be advantageously carried on are thus greatly multiplied. One of its chief merits is that it is equally applicable with comparatively little extra cost in the working, to very poor and very rich ores, for however small the resulting regulus, it will contain nearly the whole of the cobalt, nickel, copper, silver, and gold present in the furnace charge, while any lead, zinc, antimony, and arsenic will be obtained as sublimates.

NOTICES.

NOTICE TO MEMBERS.

Members are reminded that the Midsummer Subscriptions are now due. Cheques and Post-office Orders should be made payable to the order of "H. T. Wood," and crossed "Coutts and Co."

SANITARY CONFERENCE.

The Pamphlet containing a full report of the papers and proceedings of the late Conference on National Water Supply, Disposal of Sewage, and Health, will be published shortly, price 2s. 6d.

Applications for copies of the Report should be addressed to the Secretary.

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All communications for the Society should be addressed to the Secretary John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

DWELLING-HOUSES: THEIR SANITARY CONSTRUCTION AND ARRANGEMENTS.

By Prof. W. H. Corfield, M.A. M.D. (Oxon).

Lecture I.—Delivered February 17th, 1879.

Situation and Construction of Houses.

It is only necessary for me to make a few introductory remarks about climate. Although few persons can choose what part of the world they will live in, a considerable number are able to decide in what part of the country they will reside. Other things being equal, the nearer a place is to the sea, the more equable is the climate, and tho further inland the place is, the more is the climate one of extremes; so that those who wish for a moist, equable climate, with warm winters and warm nights, will choose a place by the seaside; while those who wish for a more bracing atmosphere will go further inland. In England, too, there is considerable difference, as is well-known, between the climate at various parts of the seaboard. Thus, the western coast, being exposed to the winds which pass over the Atlantic, and to the action of the moist, warm air which passes over the course of the Gulf Stream, has a warm, moist atmosphere, and a heavy rainfall; while the eastern coast, which is swept by winds that have passed across Siberia and Russia, and have only the narrow strip of German Ocean to pass over before they reach our coast, has a dry, bleak, and comparatively cold climate.

For the same reason, too, the exposition of a house, or the way in which it faces, is a matter of great importance in this climate, as is well-known; a southern exposition, for example, being warm and genial, whilst an eastern one is just the reverse.

In the neighbourhood of forests, the air is damp during a great part of the year, from the enormous amount of evaporation that takes place from the leaves of the trees, and Humboldt tells us that the large forests on the banks of the Amazon are perpetually covered with mist. Other things being equal, a bare, open country is drier and hotter than a well-wooded one.

I will divide the soils, for sanitary purposes, into two kinds—pervious and impervious; those that allow water to pass freely through them, and those that do not. Pervious soils are such as gravel, sand, and the less compact and softer limestone, which allow water to pass through their interstices, and chalk, in which the water, for the most part, travels through the fissures; and the typical impervious ones, such as the various clays, mostly named from the localities where they are best known, as the London clay, Oxford clay, Kimmeridge clay. Most of the metamorphic rocks and the hard limestones are non-porous, but have a multitude of crevices, through which the water finds its way. In the former case, the water which falls on the surface passes readily through the soil, until it comes to some impervious stratum below, over which surface it passes, until it either finds outlet at the surface of the ground where the impervious stratum crops out, or until it reaches the nearest watercourse, so that above the impervious layer, which has arrested its progress through the rocks, there is a stratum of water of a depth which will vary with a variety of circumstances—a stratum which can be reached from the surface of the ground by digging wells down to it. This water we call the "subsoil" water, or the ground water (*grundwasser*). In some instances, the impervious stratum just spoken of is placed in such a manner as to prevent the escape of the subsoil water at all, in which case the soil is said to be water-logged. The water which falls on the impervious soils, on the other hand, does not sink into the ground, but remains on the surface, or runs off if there be a suitable incline, and so such soils are necessarily damp. The diseases that are prevalent upon the pervious soils are enteric (typhoid) fever and cholera; during epidemics of that disease—diseases, in fact — the poisons are chiefly communicated by means of drinking water; and the readiness with which the subsoil water just mentioned can be contaminated by the percolation into it of foul matters from the refuse of habitations, combined with the fact that people who live on such soils, as a rule, drink water from wells dug in them, no doubt accounts for the prevalence of those diseases.

On impervious, damp soils, on the other hand, consumption, the great plague of our climate, which kills more than half as many people as all the communicable fevers put together, is prevalent, and so are lung diseases of various kinds, rheumatism, and, under special circumstances, ague. It has been clearly shown that dampness of the soil under the houses is one of the great factors in the production of consumption. Dr. George Buchanan (see 9th report of the Medical Officer of the Privy Council) demonstrated that in every instance where the level of the subsoil water in a town has been lowered, that is to say, where the distances between the basements of the houses and the level of the water in the soil had been made greater, the death-rate from consumption had decreased—in one instance to the extent of not less than 50 per cent., so that there can be no question that it is extremely important for everyone who can to live upon a dry soil. Where then, the soil is not pervious to a considerable depth below the basements of the houses, so that the level of the ground-water comes within a few feet of them, or where the soil, being itself pervious, is naturally water-logged, or in the so-called impervious soils, which

are, of course, all pervious to some extent, it is necessary to provide means whereby the level of the water shall be kept below a certain minimum depth from the foundations of the houses. This is done by drainage, and by a drain I mean a pipe or channel that is intended to remove the water from the soil. It must, therefore, be a pipe into which the water can get—that is to say, it must be pervious to water. The object of drains, then, is twofold, to carry off the surface water, and to prevent the subsoil water rising above a certain height, for as soon as it rises to the level of the drains it finds its way into them, and is carried away to the outfall at a lower point.

Drains may, therefore, be made of stones placed together without cement, as was the case with the Cloaca Maxima, the great drain which was constructed by the second king of Rome to dry the ground around the Forum; or of brickwork, with or without mortar; or, as is very commonly the case, of pervious agricultural tiles. The surface gutters must also be mentioned in connection with the drains, and they are, of course, especially necessary on impervious soils. The ultimate destination of the drains is into the watercourses, streams, rivers, &c.

So much for natural soils; but, especially in the neighbourhood of most of our large towns, many of the houses are built upon artificial soil, or "made ground" as it is called. This made ground consists of the refuse of dust-bins, ash-pits, midden-heaps, and the like, which is shot at some place where the ground requires to be raised. It is very undesirable that houses should be built on any such made ground, at any rate for a considerable period. There is no doubt, however, that, after some time, the action of the air and water in the soil causes a slow decomposition of the organic matters in it, and renders it less objectionable as a site for building purposes. Nevertheless, no one would choose to live in a house built upon "made soil" if he could help it.

The proximity of buildings is the next matter to be considered. It is important that houses should not be too near together, as otherwise both light and ventilation are interfered with, and it is now a regulation in the metropolis that a new street shall be at least as wide as the houses on either side of it are high, and that no new street shall be less than 40 feet wide.

Having determined the site on which to build, we come next to the foundations. These should not be on made ground, nor on purely vegetable soil, as peat, humus, &c. Their depth is a matter which it is the architect's province to determine, and depends upon various circumstances, such as the weight they have to support. The material used must be the best concrete. The inferior kinds, made with too little lime or cement, crumble away, allow damp air to pass through them, and make the house unwholesome, besides endangering the structure. It is important to remark here that a house should not be built, or even its foundations laid, in frosty weather, for the work will not hold when a thaw sets in.

Basement.—The covering of the ground with some impervious material is imperative, in order that the moist air from the soil may be prevented from rising into the house. In the case of made soils, the covering of the ground should extend for some distance round the house. This covering is best made of concrete some inches thick, and should be used in all cases, whether there are any underground rooms or not. Such underground rooms or basement floor should be only used as cellars—not as living rooms—and should always be arched. The concrete floor may be covered with asphalte, tiles or York paving, but wooden floors should never be used below the ground level. The walls of the house, below the level of the ground and a little above it, should be made with exceptionally good materials, and set in cement, so as to be as impervious as possible to damp. This is a matter that is very frequently lost sight of, and the walls below the level of the ground are frequently made of the worst possible materials. Being hidden from sight, it is often considered that the best materials need not be used for them. It is advisable to have a damp course in the walls all round the house, at a little distance above the ground level, whether the site be a damp one or not. This damp course may be made of asphalte, stoneware, or slate set in cement. Cement alone cannot be depended on. If such a course is not placed in the wall, moisture will rise up through the bricks by capillary attraction, and make the walls of the house damp, rendering the house itself unwholesome. The inner side of the walls in the basement floor may be advantageously made of glazed bricks or of hard black Staffordshire bricks, but no covering of any kind whatever should be placed on those walls. The money should be spent on good construction, and not on covering up bad materials. There should be a dry area all round the walls of the house outside, starting from the concrete foundations. Its width is a matter of little importance, as it is only required to ensure dryness of the walls below the level of the ground, and the ventilation of the cellars in the basement, unless, indeed, the basement rooms are inhabited, in which case, at any rate, the regulations of the Public Health Act must be complied with. This area must have proper connections with the land drains to allow of the removal of the surface water. The materials used for building the walls of the house depend upon the locality. They may be bricks, stone of various kinds (the choice of which must be left to the discretion of the architect), and, in some parts of the country, flints. Bricks stand fire better than anything else, for the simple reason that they have been already burned. This fact was remarkably shown in the great fire at Chicago, where the brick houses remained comparatively intact, while the granite ones were utterly destroyed. In any case the materials should be set in mortar or cement, and in wet and exposed positions the walls should be double or "hollow" walls, as they are technically termed. Occasionally, in such positions they should even be slated on the outside, or covered with glazed tiles. Walls are sometimes made of concrete, a very ancient plan, and not modern, as is commonly supposed. The Romans frequently used concrete walls in their aqueduct bridges and other constructions. The cement used was of extraordinary hardness, and has, I believe, never been surpassed, even if equalled, in later times. It might be called the "cement of the Romans," as the term "Roman cement" is now commonly applied to a very inferior article. In making concrete columns, the

Romans adopted the practice of inserting layers of their flat bricks, which we should perhaps call tiles, at intervals, and they faced the surface with stones, generally disposed after the fashion known as *opus reticulatum*. This consisted in placing small cubical blocks of stone against the surface of the concrete, so that the sides of the exposed faces were not vertical and horizontal, but the diagonals were, thus giving the appearance of network, or of a chess-board set up on one corner. These devices assisted greatly in protecting the structure from the weather, and from rough usage. Such walls may also be very well faced with tiles of various kinds.

The chimney flues should be as straight as possible. They should be separate from one another—a matter very often not attended to—and they are better lined with pipes, as these are much more easily cleaned; an up-draught is more readily established in them, and they completely disconne t the flue from the structure of the house, and so help to prevent destruction by fire.

It is important that the chimneys should be higher than the surrounding buildings, so that the wind may pass freely over them, and that they may not be sheltered from its action in any direction whatever. If this is not the case, there will be a down draught in the chimneys when the wind is in a certain direction, and the more the chimneys are sheltered by high buildings the more chances there are of down draughts in them. If necessary, an iron or zinc pipe called a "tall-boy," may be placed on the top of the brickwork, to increase the length of the flue. This is sometimes even carried up adjoining buildings, and is, as a general rule, better without a cowl of any kind on the top of it, as will be further explained in the next lecture.

Flooring.—Fire-proof floors are most desirable. They may be made of concrete or brick arches between iron girders, in which case there is no space between the flooring of one room and the ceiling of the room below. When timber is used, it should be dry and well-seasoned, with sound boarding, to ensure separation between the rooms, and to prevent either water leaking from the floor to the ceiling below, or air passing from the room below to that above. Good flooring evidently serves to protect the ceilings of rooms below. Where there is space between the flooring and the ceiling, and still more especially where a wooden flooring is placed over a concrete or other foundation laid on the ground, it is necessary to provide for ventilation of the space below the flooring. This is usually done by placing a perforated iron grating, instead of a brick, here and there, in the outer walls, so that air can pass freely in or out below the floors. For this purpose bricks, such as those exhibited, with conical holes through them, would no doubt be found very useful.

The Roof.—This may be constructed either of fire-proof materials, or of timber, and in either case may be covered with slates or tiles, or may be thatched; copper or corrugated iron are also used. Sometimes zinc is used on account of its cheapness. It is not a good material, as it does not last long. Lead is largely used, especially upon flat roofs, and is valuable on account of its lasting properties. Where there are eaves, it is important that they should not drip on to the walls, but project, so as to throw the water off. Cornices and all projections should be constructed so as to throw off the rain, or it will run down the walls. If this is not done, the walls will be continually damp and dirty. Rain-water gutters may be made of lead or iron. They must have a sufficient fall, and shoot directly into the heads of the rain-water pipes. They should be wide enough inside to stand in, so that the snow may be cleared out. If this is not done, it will accumulate, blocking up the channel, and when the thaw comes the melted snow will work its way through the tiles or slates of the roof, and injure the ceilings below.* Rain-water gutters should not be carried through the house from one side to the other, and especially not through bedrooms. Nor should they be carried, as is sometimes done, round the house inside the walls, and through the rooms. A more or less disagreeable smell is frequently noticed in rooms through which rain water gutters pass. The rain water pipes should also be outside the house. They should be of iron, well jointed. Galvanised iron ones are preferable; they are only a little more expensive and last much longer. They should either discharge into rain water tanks, which must be well ventilated, or on to the surface of the ground or area round the house. They should not be connected directly with the drains or sewers. Neither should they be placed with their hoppers or heads just below the bedroom windows, especially if they discharge into a tank. Large and high houses, especially if standing alone, require to be provided with lightning conductors. Copper ones are better than iron, and need not be so thick. They must be insulated from the walls of the house by suitable rings of some non-conducting material, and end in some moist place in the soil. In the case of an isolated house it is also a good plan to have a weather-cock on the roof, and connect that with a registering apparatus in the hall. An anemometer is also useful.

Thus far about the construction of the building itself. We now come to the finishing off inside. The floors should be covered with boarding—oak bees-waxed being the best, or deal, stained and varnished, may also be used. The joints are better tongued. Parquet flooring, made of teak, may be placed over the whole of the surface, the object being to ensure, as far as possible, a uniform and impervious surface, without cracks or badly made joints, in which dust can accumulate. This is especially important. Either of these plans is better than the common one of covering the whole floor with a carpet or drugget. When these are used, a border of stained and varnished or polished boards, or of parquet flooring, should be left all round the room. This has the advantage that dust does not accumulate so readily in the corners, which are more easily swept and cleaned, and the carpet can be taken up at any time to be beaten, without moving the furniture which is against the walls. The skirting boards of wooden floors should be let into a groove in the floor. This will serve to prevent draughts coming through, and dust accumulating in the apertures, which are invariably formed by the shrinking of the joints

* The remark as to the width of gutters does not apply to eaves-gutters.

and the skirting. Some floors, such as those of halls, greenhouses, &c., are best tiled.

Wall Coverings.—These, like the floors, are better made of impervious materials which can be washed. Tiles form an admirable wall covering, and are, moreover, a permanent decoration. Various kinds of plastering, with the surface painted, form a cheap and effective wall covering. Paint containing lead should, of course, not be used, but the silicate, or the indestructible paints, and zinc white should be used instead of white lead. Paper as a covering for walls has the disadvantage that, as a rule, it cannot be washed, and that the dust collects on it. For this reason, after a case of infectious disease, it is necessary as a general rule to strip the paper off the walls, whereas a painted or tiled wall can be washed. Many papers, too, are coloured with arsenical paints, and seriously affect the health of the persons living in the rooms, the walls of which are covered with them. For a considerable amount of information on this subject I would refer to a little book which has just appeared, entitled "Our Domestic Poisons," by Mr. Henry Carr.

Ceilings. — For these plastering is in most general use. It is better painted than distempered. Whitewashing, however, answers very well, and can be repeated as often as necessary. Paper should not be used for covering ceilings. If they are of wood it should be pannelled, or the joints will let dust through. The wood work generally throughout the house should be stained and varnished, polished, or painted; and generally I may sum up the principles to be followed in finishing off the inside of a house, by saying that the materials should be, as far as possible, impervious, and the surface smooth and uniform, and so disposed as to be easily cleaned, and not to collect the dust.

NATIONAL WATER SUPPLY.

SUGGESTIONS FOR DIVIDING ENGLAND AND WALES INTO WATERSHED DISTRICTS.

Essay by A. T. Atchison.

Motto.—"Water, water, everywhere,
But not a drop to drink!"*

The President and Council of the Society of Arts directed public attention, last year, to one of the most pressing and important wants of the day, when they inaugurated the Congress on National Water Supply. It is difficult or impossible to over-estimate the magnitude of the question under consideration; and, whilst the sewage difficulty, which has now for many years received great attention, is, doubtless, of vital importance, it must occupy only the position of a subsidiary element in the subject of National Water Supply.

In response to the request of the Council of the Society for suggestions founded on evidence already published, for the division of England and Wales into districts, with the object of securing a supply of pure water to the towns and villages in each district, the following outline of a scheme has been prepared.

All divisions, unless specially made for each purpose they have to serve, must necessarily be arbitrary, as is too apparent in the ancient boundaries of counties or parishes, or in the new boundaries proposed for local board districts or borough extensions.

It has been frequently laid down, as an inviolable maxim in the demarcation of districts for purposes of river conservancy and water supply, that the water-shed should be the boundary. This though the primary basis adopted, has not been arbitrarily adhered to. A careful examination of the distribution of the population was first made with the view of ascertaining what localities appeared, *prima facie*, in most need of relief.

It was at first attempted to indicate approximately the relative distribution of the population, by drawing circles whose areas were proportional to the number of inhabitants round each of the principal towns and cities, but it was soon found that if the scale of area to number was made sufficiently large to give any indication in the more sparsely populated districts, the effect became delusive in the denser parts, owing to the overlapping of the circles.

It was therefore decided—bearing in mind that the proposed scheme of dividing the country into hydrographical districts was necessarily of a large and comprehensive, rather than of a minute and detailed nature—that a map indicating the average density of population throughout an entire county would be sufficiently approximate for the purpose. With this view, the accompanying map has been prepared. Still further to simplify matters, the 54 counties in England and Wales (the sub-divisions of Yorkshire being treated as separate counties) have been divided into five different groups, in order of the average density of their population.

Table I. shows the area, population, increase per cent. in the last three decennial periods, and

TABLE I.

Population of England and Wales, with Decennial Rate of Increase.

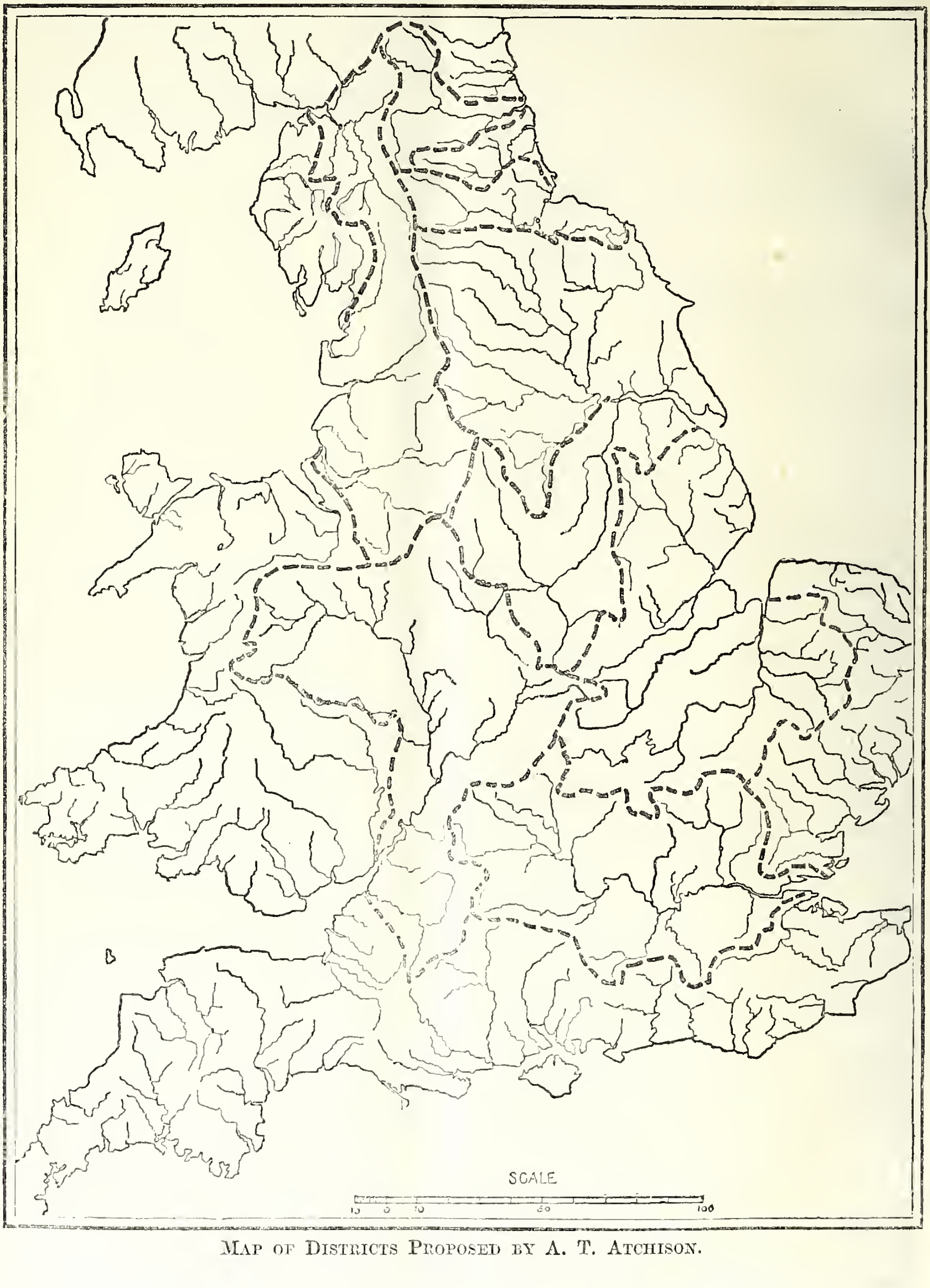
Year.	No. of Persons.	Per cent.	Year.	No. of Persons.	Per cent.
1801	8,892,536	....	1851	17,927,609	12·65
1811	10,164,256	14·30	1861	20,066,224	11·93
1821	12,000,236	18·06	1871	22,712,266	13·19
1831	13,896,797	15·80	Probable 1881	26,006,098	14·51
1841	15,914,148	14·52			

* Two Essays were sent in with this motto.

TABLE II.

	Area in Acres.	Population in 1871.	Increase per cent. in 10 years.			Persons per 100 acres, 1871.
			1841—1851.	1851—1861.	1861—1871.	
I. England:—						
Westmoreland	500,906	65,010	3	4	7	13
Yorkshire, North Riding	1,361,664	293,278	5	14	20	21
Cumberland	970,161	220,253	10	5	7	22
Hereford	532,898	125,370	2	7	1	23
Rutland	94,889	22,073	8	−5	1	23
Lincoln	1,767,962	436,599	12	1	6	24
Huntingdon	229,515	63,708	10	0	−1	27
Salop	841,167	248,111	2	5	3	29
Wales:—						
Radnor	276,552	25,430	−3	3	0	9
Merioneth	385,291	46,598	−1	0	20	12
Brecon	460,158	59,901	11	0	−3	13
Montgomery	485,351	67,263	−3	−1	1	14
Cardigan	443,387	73,441	3	2	2	16
Carmarthen	606,172	115,710	4	1	4	19
Pembroke	393,682	91,998	7	2	−4	23
Anglesey	193,511	51,040	13	−5	−7	26
Denbigh	392,005	105,102	5	9	4	27
Carnarvon	369,482	106,121	8	9	11	29
II. England:—						
Northumberland	1,290,312	386,646	14	13	13	30
Wiltshire	859,303	257,177	−1	−2	3	30
Dorset	627,265	195,537	5	2	4	31
Norfolk	1,356,173	438,656	7	−2	1	32
Cambridge	524,926	186,906	13	−5	6	35
Yorkshire, East Riding	750,828	268,466	13	9	22	35
Devon	1,655,161	601,374	6	3	3	36
Buckingham	467,009	175,879	5	3	5	37
Suffolk	949,825	348,869	7	0	4	37
Northampton	629,912	243,891	7	7	7	38
Oxford	470,095	177,975	4	0	4	38
Cornwall	869,878	362,343	4	4	−2	41
Berkshire	450,132	196,475	5	4	11	43
Essex	1,055,133	466,436	7	10	15	44
Somerset	1,049,815	463,483	2	0	4	44
Sussex	934,006	417,456	12	8	15	44
Bedford	295,509	146,257	15	9	8	49
Herts	391,141	192,226	7	4	11	49
Wales:—						
Flint	169,662	76,312	2	2	9	45
III. England:—						
Leicester	511,719	269,311	7	3	13	52
Southampton	1,032,105	544,684	14	19	13	52
Monmouth	368,399	195,448	17	11	12	53
Derby	656,243	379,394	9	15	12	57
Nottingham	526,176	319,758	8	9	9	60
Gloucester	804,977	534,640	6	6	10	66
Worcester	472,453	338,837	11	11	10	72
Chester	705,493	561,201	15	11	11	79
Kent	1,004,984	848,294	12	19	16	84
Wales:—						
Glamorgan	547,070	397,859	35	37	25	72
IV. England:—						
Durham	647,592	685,089	27	30	35	106
Yorkshire, West Riding	1,770,359	1,874,611	14	14	21	106
Warwick	566,458	634,189	18	18	13	112
Stafford	732,434	858,326	19	23	15	117
V.						
Surrey	483,178	1,091,635	17	22	31	225
Lancaster	1,207,926	2,819,495	22	20	16	233
Middlesex	181,317	2,539,765	20	17	15	1,401

Note.—Decrease of population is shown by a minus sign, thus —5



Map of Districts Proposed by A. T. Atchison.

density of population in 1871, as represented by the number of persons per 100 acres. The watersheds, or boundaries of catchment basins, were then laid down on the map, from the map of river basins contained in the 6th Report of the Rivers Pollution Commission, and special attention was directed to those basins shown to be most densely populated. The hydrographical districts being thus provisionally laid down, the whole of the principal towns were then tabulated, with their population and geological formation, and all the available information sought respecting the source, quality, and quantity of their water supply. It need hardly be said that, with the

exception of those places which furnished information on the subject to the Rivers Pollution Commission, and in answer to the inquiries of the Society of Arts last year, and a few others, very little material is to be found for forming a judgment of the nature of their supply. It was found that, in a great majority of towns, an adequate supply of good water was either in their possession or within easy reach, but in a great number of these instances the danger or certainty of future pollution of the pure sources is at once apparent.

There are, however, some large towns, or groups of towns, which are so situated as to render it almost impossible for them to obtain a sufficient quantity of pure water within their own river basin. It is these towns that show the necessity of the legislation ultimately contemplated by this Congress. If a district finds itself unable to procure a good and adequate supply near home, it naturally casts its eyes abroad. Selecting some, as yet, unappropriated source, Parliamentary powers are sought, and perhaps obtained, in spite of opposition, and a catchment area allotted to a district at a distance, to the exclusion of one nearer. Thus it has happened, and doubtless will happen again, that an excellent source placed by nature within the grasp of the inhabitants in need of it, has, by their supineness, been allowed to pass into the hands of others. The great object, then, of dividing the country into districts, is to secure to those towns and villages the possession of the sources most favourably situated for their use at whatever time it seems good to them to take them, and at the same time to ensure that no community shall in future be cut off from all chance of a good supply, provided they take in good time the proper measures to preserve its purity.

All that is attempted in this paper is to give a preliminary sketch of the main outlines of these districts. It will readily be seen that if the districts are too large, almost all the evils necessitating their formation will recur, only perhaps on a smaller scale. Thus, for example, while London is prevented from taking the supply best adapted to Manchester and its neighbourhood, Leeds might still acquire that which should be reserved for Bradford. As already stated, these primary divisions were first tentatively made conterminous with the principal river basins, when it was found on examination that the population, with every allowance for prospective increase, had within their district an ample supply of unpolluted water, and that no neighbouring district was by the provisional boundary cut off from their only chances of an adequate supply in the future, then that boundary was decided on. When, however, it was found that the provisional boundary of a district did not enclose sources considered sufficient for future requirements, that boundary was abandoned, and the whole or parts of neighbouring districts included with it.

After due consideration of the facts obtainable, it is believed that the primary divisions shown on the map will, in the main, meet the requirements of the case, but in thus foreshadowing the direction in which steps should be taken, it must be borne in mind that a careful survey of the ground, and a more ample collection of statistics, must cause much alteration in detail. It is foreseen that, before division of the country into primary districts is of much practical benefit to the inhabitants, that a further sub-division into sub-districts will be necessary; but before this can be accomplished with any certainty of success, the measures recommended in the resolution of last year's Congress must be adopted. A vast amount of detailed information, in the form of observations, reports, plans, and gaugings, exists in the hands of companies, corporations, engineers, and chemists, which has never yet been made public, and which might be rendered available. Mr. G. J. Symons, F.R.S., has for a great number of years devoted himself most indefatigably to the enrolment of an immense staff of rainfall observers, and to the tabulation and comparison of their returns. The British Association, through their Committee on Underground Waters, has done much valuable work in a parallel direction, while Messrs. Baldwin Latham and Lucas are pursuing investigations of an equally useful nature; but, unless we are contented to wait for a century at least, the attainment of the object in view must not be left to private enterprise. The appointment of a permanent Commission or department "to investigate and collect the facts connected with water supply in various districts throughout the United Kingdom, in order to facilitate the utilisation of the national sources of water supply for the country at large" is indispensable, and, further, to strengthen their hands, it should be enacted that every corporation, company, local board, or other body exercising powers conferred under Act of Parliament be compelled to furnish to the department a copy of every report, analysis, plan, section, gauging, or other observation received by them on the subject of water supply, drainage, or river conservancy.

The question of river conservancy, considered as bearing on the control of rivers, and which is at present before the Houses of Parliament, is intimately bound up with that of national water supply. It is of the greatest importance, then, that any legislation which is undertaken should pay due regard to both. The primary divisions will now be considered in detail.

Thames District.

This district has a present population of about 5,193,000. Rainfall varying from 24 to 34 inches per annum, and averaging about 26 inches. Geological formations, middle and lower oolite, chalk, lower greensand, and London clay. The water supply of London and its suburbs, constituting a population within the Metropolitan Police area of 3,885,641, in 1871, or, at the last decennial rate of increase, 4,463 816 in 1879, is by far the most important element of consideration in this district. To dissect and analyse the vast amount of evidence that has been collected on the present state of the metropolitan supplies, or to discuss the various proposals that have been for many years made for their improvement, would be quite beyond the scope of the present paper. It is no use shutting our eyes to the fact, that the present supply of Thames water delivered in London is largely contaminated by the washings from highly cultivated lands, the discharges from paper mills, tanneries, and other manufactories, in addi-

tion to the sewage of 900,000 persons, the bulk of which is but imperfectly cleansed before admission into the river.

A slight freshet, particularly in summer, serves at once the purpose of flushing the accumulated filth from the river, and enriching the product delivered to the consumer.

By the enlargement of subsiding reservoirs, and the exclusion of flood waters, accompanied by careful and efficient filtration, the character of the water can, doubtless, be rendered comparatively inoffensive; but the fact will still remain that the diluted washings and excreta of the human and animal inhabitants of the catchment basin above the intakes, are still drunk by those addicted to this beverage. The same remarks apply to the River Lee water, but with greater intensity from the larger proportion of its normal flow, which is abstracted for the London supply. The day cannot be far distant when the present supply will be abandoned; but whether an entirely new supply must be sought, or merely a pure supply for drinking and cooking purposes, need not be here discussed. The proposals for obtaining a supply of the highest excellence from North Wales or the Cumberland lakes are, doubtless, not only practicable, but not out of all proportion costly.

In considering the division of the country into hydrographical districts, with due regard to the density and rate of increase of the population, it appears at once unfair to allot either of the above catchments to the metropolis, and that such heroic measures are entirely unnecessary can be shown by an examination of the Thames basin.

It has been stated (Sixth Report Rivers Pollution Commission) that the chalk and upper greensand formations cover an area of 849 square miles within a 30 miles radius of London, 1597 square miles within 40 miles, and 2,150 square miles within that portion of the Thames basin lying within a 50 miles radius. Now, half an acre of catchment is sufficient for a supply of 30 gallons per diem per inch of available rainfall. Taking the available rainfall as $2\frac{1}{2}$ inches, or less than the equivalent of the mean dry weather flow of the entire Thames basin (2·93 inches per annum), each acre of catchment will provide five persons with 30 gallons per head, and 2,150 square miles will suffice for the same supply per head to $5 \times 2{,}150 \times 640 = 6{,}881{,}000$ persons. Although it might be unwise to calculate on a very much larger supply per acre than the amount here taken, experiments extending over a number of years have shown that this estimate is well within the mark. Of the purity of the water obtained from these sources there can be no question, and if the supply for domestic purposes be first treated by Dr. Clark's softening process, no exception can be taken to it on the score of hardness.

The Commissioners on Water Supply, discussing this source, observe, "moreover, as the water which penetrates into the reservoir (*i.e.* the subjacent chalk) raising the water line more or less above the level of the adjoining valleys, ultimately in greater part finds its way by springs into streams at the lower level of the district, any water drawn from the store, by artificial means, will most probably be at the expense of these streams. If this be true, it follows that any water obtained by tapping the chalk reservoirs that feed the River Lee or the Thames would only, *pro tanto*, diminish these streams, and would, therefore, be little or nothing gained to the general supply."

It is here maintained that this deduction of the Commissioners will not be borne out by fact, for the following reasons:—That much water absorbed by the chalk on the south side of the basin finds its way direct into the tidal channel of the river, and might, therefore, be intercepted and rendered available by pumping; that the absorptive capacity of the chalk and other porous formations would be increased by pumping from deep wells, the natural underground channels being cleared and enlarged thereby, the hydraulic inclination increased, and the drainage of the upper strata thus accelerated.

Another consideration, affecting the volume of the rivers laid under contribution for the supply of the metropolis, has been lost sight of by the Commissioners. An inspection of the diagrams, in the Sixth Report, showing the daily flow of the Thames, proves the truth of the recommendation of the Commissioners that "nothing less than 80 or 90 days' storage will render them (the Water Companies) independent of flood-water in autumn and winter." When the river, after long-continued floods, has resumed a fit condition for taking into the works, not only has it to meet the daily demand, but also to supply the much greater draught on its flow, for the replenishment in a few days of the whole of the nearly exhausted store. It may thus occur that at times a large proportion, or the whole even, of the dry weather flow is being abstracted by the works. Unless other sources are obtained, the growth of the metropolis, and the increased storage provided by the companies, will soon render this evil apparent. In pumping from deep wells for the supply of the metropolis, the loss to the river of that portion of the water only which is intercepted from the non-tidal part of the river will be felt, and the demand being spread uniformly over times of flood and drought, in place of being made, as in the previous case, only during the period of normal flow, will cause a much less serious diminution.

Thames Basin.

Abingdon.—Upper greensand; population, 5,809.

Aylesbury.—Upper oolite; population, 6,962.

Banbury.—Lias; population, 11,726. From the Cherwell; much polluted by sewage and animal matter, and too hard for washing.

Basingstoke.—Chalk; population, 5,574. Well in chalk; 130,000 gallons pumped to reservoir daily; constant service, 40,000 gallons of which to 300 houses, 80,000 to 10 works and manufactories, also railway station. Supply bright, clear, and wholesome, but too hard for washing.

Cirencester.—Middle oolite; population, 4,685.

Croydon.—Chalk and clay; population, 55,652. Deep wells in chalk. About 45 gallons per head.

Godalming.—Lower greensand; population, 2,444.

Guildford.—Chalk; population, 9,106.

Hemel Hempstead.—Chalk; population, 5,996.

Hertford.—Chalk; population, 7,169. From wells. About 30 gallons per head.

Oxford.—Middle oolite; population, 31,404.

Reading.—Chalk; population, 32,324.

Richmond.—London clay; population, 15,110. Supplied formerly by Southwark and Vauxhall, but a new supply is being laid on from deep wells.

St. Alban's.—Chalk; population, 8,303. Deep well in chalk. 100,000 gallons daily.

STAINES.—Alluvian; population, 3,464.

SURBITON AND KINGSTON.—Alluvian; population, 15,263 and 7,642. Lambeth Water-works.

TEDDINGTON.—Alluvian; population, 6,000. Grand Junction.

TWICKENHAM.—Alluvian; population, 10,533.

WATFORD.—Chalk; population, 7,461.

WINDSOR.—London clay; population, 11,769, and Eton 4,000. From shallow wells, and well sunk on island in Thames; fairly good, but too hard.

NORTH-WESTERN DISTRICT.

This district, including the most densely populated part of the British Isles, contains a population of 3,666,000. The rainfall varies from 30 to 100, and probably averages about 45 inches. The principal geological formations are millstone grit, coal measures, magnesian limestone, and new red sandstone. The bulk of the population is located in large towns in the Mersey basin. An inspection of the accompanying statistics of the water supply of the 21 principal towns within the Mersey basin, shows them to be mostly supplied with a sufficient quantity of water of a good quality, better in most cases than that in use in the metropolis. The evidence, however, points to the fact that the underground sources are in danger of considerable pollution in this densely populated district, and, therefore, that too great reliance should not be placed on the otherwise unfailing source of supply—the new red sandstone. These things considered, and in view also of the fact that the Corporation of Manchester has succeeded in establishing a claim on the Lake district, it has been deemed advisable to unite the basins of the Mersey, Ribble, Lune, and Eden, in one district. An ample supply being thus secured for the most remote future, with the object of preserving part of the Lake district from real or fancied detriment, the basins of the Derwent, Ehen, Irk, Crake, and Leven, have been excluded, with the exception only of a small portion of the Derwent basin, which it is probably too late to rescue.

MERSEY BASIN.

ALTRINCHAM. — New red sandstone; population, 8,478.

ASHTON-UNDER-LYME.—Coal measures; population, 31,985. Gravitation; constant service; 600,000 gallons daily; 600 acres catchment; five reservoirs, capacity 450,000,000 gallons; Swineshaw's reservoirs supply Ashton and Staleybridge; new works in progress.

BACUP.—Coal measures; population, 18,200. Gravitation; intermittent in dry weather; 96,000 gallons daily, domestic; 64,000 gallons to works; 350 acres catchment; reservoir capacity, 14,000,000 gallons for domestic supply, 8,000,000 gallons for works; wholly inadequate.

BIRKENHEAD. — New red sandstone; population, 45,418. Wells in new red sandstone 399 ft. and 527 ft. to bottom of boreholes; supply pumped into reservoir; 1,867,000 gallons daily; excellent quality and fully adequate.

BOLTON.—Coal measures; population, 90,000. Gravitation; constant service; 3,000,000 gallons daily for domestic and trade purposes; 27,000 houses, 628 works and manufactories; 3,200 acres catchment; five reservoirs, capacity 935,000,000 gallons; supply abundant.

BOOTLE.—New red sandstone; population, 16,247. Supplied by Liverpool Corporation from wells in new red sandstone.

BURY.—Coal measures; population, 38,000. Gravitation; constant service; 1,500,000 gallons daily; 18,724 houses, 547 works and manufactories; 3,675 acres catchment; six reservoirs on millstone grit, capacity 625,000,000 gallons; soft, and of excellent quality but for a small amount of sewage contamination.

CONGLETON.—New red sandstone; population, 11,344. Filtered sewage from wells, too hard for washing.

GLOSSOP.—New red sandstone; population, 17,600. Gravitation, and from streams and springs.

HASLINGDEN.—Millstone grit; population, 7,698.

HEYWOOD AND MIDDLETON.—Coal measures; population, 21,248. Gravitation, 700,000 gallons daily; 7,000 houses, 150 manufactories, 1,260 acres catchment; storage reservoir 506,000,000, service 338,000,000. Supply filtered before entering service reservoir.

KNUTSFORD.—New red sandstone; population, 3,597.

LIVERPOOL.—New red sandstone; population, 493,405. Gravitation, and from wells in new red sandstone; constant service, 14,000,000 gallons daily; 99,284 assessments, 775 works, &c.; 10,000 acres catchment upon Rivington Pike; reservoirs, 3,268,000,000 gallons. Gravitation supply is filtered, and superior in quality to that from the wells. It is at present adequate.

MACCLESFIELD. — New red sandstone; population, 35,375. Gravitation, 1,000,000 gallons daily; 8,637 houses, 56 works, &c.; 2,000 acres catchment at Langley; reservoirs, 177,000,000 gallons. Slight previous animal contamination, but in other respects excellent.

MANCHESTER.—New red sandstone; population, city; 355,665; total population, including Salford, 750,000. Upland gathering ground; constant service, 14,500,000 gallons daily for consumption, 14,000,000 gallons daily for compensation; 137,250 houses, 9,416 works, &c.; 19,300 acres catchment; storage reservoirs, 4,599,000,000 gallons. Supply generally adequate, soft, and well adapted for manufacturing purposes, but rather peaty.

NANTWICH.—New red sandstone; population, 6,673. Walverden stream, springs, and gathering ground, 140,000 gallons daily; 2,293 houses, 26 works, &c.; reservoirs, 2,000,000 gallons.

OLDHAM. — Coal measures; population, 82,619. Gathering ground at sources of Irwell and Medlock; constant service, 2,500,000 to 3,000,000 gallons daily; 2,700 acres catchment; reservoirs, 742,000,000 gallons.

ROCHDALE. — Coal measures; population, 64,000. Gathering ground, 700 acres; constant service, 750,000 gallons daily; 13,000 houses; reservoirs, 150,000,000 gallons. Supply of first-rate quality.

RUNCORN.—New red sandstone; population, 12,443. Well in sandstone; water hard, but not otherwise bad.

SANDBACH.—New red sandstone; population, 5,295. Private shallow wells.

STALYBRIDGE.—Coal measures; population, 21,042. Gathering ground, 280 acres; constant service; 100,000 gallons daily; 5,000 houses, 10 mills; storage reservoirs, 48,000,000; high service reservoirs, 25,000,000; supply inadequate, and supplemented by Manchester Water-works.

STOCKPORT.—Red marl; population, 53,014. From gathering grounds, 850,000 gallons; from Manchester Water-works, 300,000 gallons daily; constant service; 1,150,000 gallons daily; 13,500 houses, 370 factories; supply filtered, but not of a satisfactory quality.

ST. HELEN'S.—Coal measures; population, 45,000. Gathering ground 300 acres for trade supply; boreholes in new red sandstone for domestic use; intermittent service; 650,000 gallons daily to 700 houses; 800,000 gallons daily to 100 works, &c.; domestic supply of the very best quality.

WARRINGTON.—New red sandstone; population, 32,000. Well in new red sandstone; 200,000 gallons daily to 4,500 houses; 200,000 gallons daily to mills and factories.

Ribble Basin.

BLACKBURN.—Coal measures; population, 78,000. Gathering ground, 800 acres; constant supply; 1,200,000 to 1,500,000 gallons daily; 18,000 houses, 270 works; storage 447,000,000 gallons; soft and free from previous

sewage contamination; adequate, but powers being sought for further catchment of 1,620 acres.

Burnley.—Coal measures; population, 40,900. Gathering ground, 1,000 acres; 9,070 houses, 200 manufactories; reservoir, 54,450,000 gallons.

Chorley.—Coal measures; population, 16,864. Gravitation; constant service; 400,000 to 500,000 gallons daily; 3,000 houses, 50 manufactories; reservoirs, 72,000,000; supply filtered, free from pollution; good soft mountain water, but strongly impregnated with peaty matter.

Clitheroe. — Carboniferous limestone; population, 8,208. Adequate constant service from springs on the moors.

Colne.—Millstone grit; population, 7,325. Supplied from a gathering ground, unfiltered, in summer not more than five gallons per head.

Preston.—New red sandstone; population, 86,000. Gathering ground, 2,878 acres, half upon limestone and from River Loud; constant service; 2,305,500 gallons daily to houses, 751,000 to 500 manufactories; 17,930 houses in borough, 1,014 in neighbouring places; storage reservoir, 264,847,000 gallons, service reservoir, 52,173,000 gallons. Supply rather hard and peaty, but exhibits no previous animal contamination; works in progress for obtaining further amount from sources of the Hodder.

Settle.—Millstone grit.

Wigan.—Coal measures; population, 39,110.

Lune Basin.

Kirby Lonsdale.—Millstone grit; population, 1,766.

Lancaster.—Millstone grit; population, 17,034. Direct from springs on Bleasdale Fells on the millstone grit; 700,000 gallons daily. Supply delivered unfiltered, is soft, and of excellent quality.

Sedberg.—Upper silurian.

Eden Basin.

Appleby.—Red marl; population, 2,000. From Stockgill Brook, above town. Supply soft, and of a high degree of purity.

Carlisle.—New red sandstone; population, 31,049. From the Eden 1,061,000 gallons daily; 5,000 houses, 20 manufactories; service reservoir, 843,750 gallons. Supply is filtered, but has been polluted by the sewage of villages above.

Penrith.—Red marl; population, 8,317.

Shap.—Carboniferous limestone.

Severn District.

This district, including South Staffordshire, contains a population of about 2,630,000. The rainfall varies from 23 to 46, and probably averages about 28.

The principal geological formations in the district are upper and lower silurian, Devonian, trias, and oolite.

The upper tributaries of the Severn have been brought into prominence as a proposed source of supply to the metropolis, and the abundance and good qualities of their water are well known.

From the inspection of the geological map, and such scanty information as can be obtained respecting the water supply available for the South Staffordshire district, it appears that the dense mass of population congregated in this area must eventually seek help outside their own catchment basin. It has been considered necessary, therefore, to include this area with that of the Severn basin, to some parts of which its population must some day look for an increased supply. Within this district abundance of water exists, in most cases in easy reach, and the wonder is that places like Shrewsbury, Worcester, and Tewkesbury, for example, are contented with a polluted supply from the river.

Severn Basin.

Bridgenorth.—Permian; population, 5,876.

Cheltenham.—Lias; population, 44,519. Springs at Leckhampton and Hulett's Hill, and shallow wells. Intermittent service; 300,000 gallons daily; storage, 35,000,000 gallons; clear and palatable, fairly soft. 10,000 of the population obtain a dangerous supply from shallow wells.

Coalbrookdale and Ironbridge.—Coal measures; population, 9,500.

Coventry.—Permian; population, 37,670.

Evesham.—Lias; population, 4,888.

Great Malvern.—New red sandstone; population, 5,693.

Gloucester.—Lias; population, 18,330. Catchment, 1,500 acres; 500,000 gallons daily; storage and subsidence reservoirs, 62,000,000 gallons; service, ditto, 54,000,000 gallons; 3,900 houses, 80 manufactories; supply not filtered; shows no signs of previous sewage contamination, is hard and turbid, and needs filtration.

Kidderminster.—New red sandstone; population, 19,463. Private wells and river water carried round in casks. Splendid water might be obtained from the sandstone on which the town stands.

Leamington.—New red sandstone; population, 20,917. Since February, 1879, a pure supply has been obtained from an artesian well, yielding 2,000,000 gallons daily. Excellent water, but rather hard.

Ledbury.—Old red sandstone; population, 2,967.

Ludlow.—Old red sandstone; population, 5,087.

Montgomery.—Upper silurian; population, 1,285.

Newtown.—Upper silurian; population, 5,000. Shallow wells.

Newport.—New red sandstone; population, 27,067.

Oswestry.—Coal measures; population, 7,306.

Rugby.—Lias; population, 8,385.

Shiffnal.—New red sandstone; population, 2,190.

Shrewsbury.—Permian; population, 23,300. From Severn, 500,000 daily; intermittent, unfiltered, and not of a good quality.

Stourbridge.—New red sandstone; population, 9,376.

Tewkesbury.—Lias; population, 5,409. Pumped from Severn above town; supply filtered and moderately hard, but of bad quality, brownish and unpleasant from peat.

Warwick.—New red sandstone; population, 10,986. From gravel overlying new red sandstone, 280,000 gallons daily.

Wellington.—New red sandstone; population, 5,926. Gravitation from catchment on the Wrekin.

Welchpool.—Upper silurian; population, 7,318. Constant service; 150,000 to 200,000 gallons daily from gathering ground; supply adequate.

Worcester.—New red sandstone; population, 33,225. From a few wells and the Severn.

Avon Basin.

Bath.—Lias; population, 52,548. Springs in upper lias. 402,000 gallons daily to 4,650 houses, 30,000 gallons daily to 71 breweries and soda-water factories; supply excessively hard and inadequate.

Bristol.—Coal measures; population (including Clifton), 182,552. Springs on Mendip Hills; new red sandstone conglomerate, and at Barrow mountain, limestone and conglomerate; also wells in new red sandstone; 3,500,000 gallons daily; storage reservoirs, 332,000,000 gallons; service reservoirs, 11,500,000 gallons; supply fairly good, but very hard.

Frome.—Middle oolite; population, 9,752. Wells and springs; supply inadequate and too hard; a considerable amount is drainage from churchyard.

Trowbridge.—Middle oolite; population, 11,500. From private wells; supply inadequate; new well and borehole in lias in progress.

Upper Trent Basin.

Atherstone.—New red sandstone; population, 3,667. Shallow wells; supply from a higher spring proposed.

Birmingham. — New red sandstone; population. 343,787. Three-quarters from wells and boreholes in and through bed of new red sandstone, the remainder from head waters of the Tame; constant service; 7,500,000 gallons daily; 68,532 houses, besides works, &c.; storage 200,000,000, new reservoirs to be constructed to hold 300,000,000 gallons.

Bilston. — Coal measures; population, 24,000. Supplied by Wolverhampton.

Burslem. — Coal measures; population, 25,562. Supplied by Staffordshire Potteries Water-works from borehole in new red sandstone conglomerate; adequate supply, clear and wholesome.

Burton.—Keuper marl; population, 20,378.

Hanley.—Coal measures; population, 39,976. From springs; 800,000 gallons daily.

Lichfield.—Keuper marl; population, 7,347.

Longton.—Coal measures; population, 19,748.

Newcastle-under-Lyme.—Coal measures; population, 15,948.

Nuneaton.—New red sandstone; population, 7,399.

Rugeley.—Keuper marl; population, 3,375.

Stoke-upon-Trent. — Coal measures; population, 15,300.

Stafford.—Keuper marl; population, 14,437.

Tamworth.—Keuper marl; population, 4,589.

Wallsall.—Coal measures; population, 46,447.

Wednesbury.—Coal measures; population, 23,030.

West Bromwich.—Coal measures; population, 47,918. Wells and South Staffordshire Water-works.

Willenhall.—Coal measures; population, 15,902. Supplied by Wolverhampton.

Wolverhampton.—Coal measures; population, 70,000. Small amount from wells, the remainder pumped from streams; constant service; 1,600,000 gallons daily, of which 1,110,000 to 13,729 houses, 490,000 to 150 works; storage reservoir, 11,000,000, service reservoir, 700,000; supply not filtered.

Aire District.

This district, including the basins of the Aire, Wharfe, and Don, contains a population of about 1,803,000. The rainfall varies from 25 to 35, and averages about 28.

The principal geological formations in the district are millstone grit, coal measures, magnesian limestone, trias, and oolite. Upland surface waters from the millstone grit, soft, and of a good standard of purity, form the supply of the principal towns in this district. The works appear capable of further development.

In the main, if the resources at hand were properly made use of, no scarcity need be felt, and no polluted water need be supplied, but more extensive combination is evidently needed to lay the more distant and unpolluted sources under contribution.

Aire Basin.

Barnsley. — Coal measures; population, 23,021. Storage reservoirs on millstone grit, 690,630 gallons daily.

Batley.—Coal measures; population, 22,000. From gathering ground; constant service; 400,000 gallons daily; 3,000 houses, 100 works, &c.; storage, 300,000,000 gallons; supply is soft, and shows no previous animal contamination, but should be filtered.

Bingley.—Millstone grit; population, 9,000. Partly supplied by Bradford, partly from springs; amount inadequate.

Bradford. — Coal measures; population, 145,830. Gathering ground 11,000 acres, on millstone grit; constant service; 6,500,000 gallons daily; 28,000 houses, 800 works, in addition to neighbouring places; storage, 835,000,000 gallons; high-level service from millstone grit, soft, but sometimes peaty; intermediate, partly from springs in the same strata equally soft, but more palatable; low-level service from grit and limestone rather harder, but shows no previous animal contamination.

Chesterfield.—Coal measures; population, 11,427.

Dewsbury.—Coal measures; population, 24,773. Gathering ground, 2,000 acres; constant service; 750,000 gallons daily; 4,000 houses, 130 works, &c.; inadequate, but power obtained for additional supply.

Doncaster.—New red sandstone; population, 18,768. Supply chiefly from River Don, polluted by sewage of Sheffield, Rotherham, and other places.

Halifax. — Millstone grit; population, 65,800. Gravitation, 8,000 acres catchment on millstone grit; 3,700,000 gallons daily; 2,000,000 compensation; 13,000 houses, besides manufactories; storage, 658,000,000 gallons; water soft, and would be of the finest quality if previously filtered to remove suspended impurities.

Huddersfield.—Coal measures; population, 70,250. Gathering ground, 5,000 acres; 12,000 houses, 80 works, &c.; storage, 69,000,000 gallons; supply inadequate.

Keighley. — Millstone grit; population, 20,000. Gravitation, chiefly from springs on a catchment of 2,320 acres; storage, 256,250,000 gallons; supply not filtered.

Leeds. — Coal measures; population, 272,629. Gathering grounds, 1,200 acres, and some pumped from the Wharfe and Washburn; constant service; 56,908 houses, 2,500 works, &c.; supply adequate, of moderate hardness, clear, but rather peaty, that from the Wharfe and Washburn polluted by sewage of Otley, Birley, and other places.

Rotherham.—Coal measures; population, 25,087.

Sheffield.—Coal measures; population, 239,947. Upland surface water from millstone grit; constant service; 5,000,000 gallons daily; 50,000 houses, 700 works, &c.; storage, 1,538,000,000 gallons; service reservoirs, 25,000,000 gallons; water soft, and well adapted for washing and manufactures, turbid, and rather peaty, but of fairly good quality, and adequate for a much larger population.

Skipton.—Carboniferous limestone; population, 6,072. Catchment, 230 acres; 151,800 gallons daily; 1,160 houses, besides manufactories; storage, 2,625,000 gallons. Supply inadequate in dry weather, and has failed; powers obtained to get 300,000 gallons daily additional of a softer quality from a catchment on the millstone grit.

Wakefield.—Coal measures; population, 28,079. ¼ from springs, ¾ from polluted Calder; constant service. Intake situated below outfall of main sewer; supply consists of filtered sewage of a greenish yellow colour, taken from a stream in a black and putrescent condition. Powers being sought for upland supply from River Don.

Ouse and Derwent Basins.

Harrowgate.—Millstone grit; population, 6,843.

Knaresborough.—Magnesian limestone; population, 5,205. Pumped from Nidd into subsidiary reservoir, 257,000 gallons; 90,000 gallons daily; 1,376 houses; supply filtered, good, wholesome, and soft, and shows no previous sewage contamination.

Northallerton.—New red sandstone; population, 2,663. Supplied from private wells.

Richmond.—Carboniferous limestone; population, 4,443.

Ripon.—Magnesian limestone; population, 6,806. Pumped from Ure; new supply being sought; water from millstone grit of the best quality at hand.

Thirsk.—New red sandstone; population, 5,734.

York.—New red sandstone; population, 50,765. Pumped from Ouse 1½ mile above city; constant service; 1,440,000 daily; subsiding reservoirs, 2,250,000 gallons; 10,500 houses, 162 business establishments; supply filtered, hard, and unfit for washing, is clear and palat-

able, but shows signs of mixture with sewage of Borobridge and other places.

Trent District.

Population of district, 969,000. Geology, carboniferous, permian, and trias; rainfall, from 23 to 33, averages about 26. The principal towns of this district are situated on the new red sandstone, from which an abundant supply of good water can in almost every case be procured.

Derby.—Keuper marl; population, 49,810.
East Retford.—Bunter; population, 3,194.
Leicester.—Keuper and lias; population, 95,220. From reservoir on brook; supply turbid and requires filtration.
Loughborough.—Keuper; population, 11,588.
Mansfield.—Bunter, population, 11,824.
Nottingham.—Keuper marl; population, 86,621. Wells in new red sandstone; abundant, supply of excellent quality yielded by wells.
Newark.—Keuper marl; population, 12,195. From Trent two miles above town; constant service; filtered and pumped to service reservoir, which contains 500,000 gallons; slightly turbid and very hard.

Tyne District

Population of district, 470,000. Geology, coal measures, millstone grit, and carboniferous limestone. Rainfall varies from 27 to 50, and averages about 30.

Gateshead.—Coal measures; population, 48,627.
Hexham.—Mountain limestone; population, 5,331.
Jarrow.—Coal measures; population, 18,179.
Newcastle-upon-Tyne.—Coal; population, 133,678. Gravitation and pumping; constant service, 4,700,000 gallons daily for domestic purposes, 3,000,000 gallons to works and manufactories; catchment 17,000 acres; nine reservoirs, capacity 1,000,000,000 gallons; supply filtered.
South Shields.—Coal measures; population, 45,336.
Tynemouth. — Magnesian limestone; population, 38,941. Springs and shafts in coal measures and magnesian limestone; constant service; 530,000 gallons daily; supply filtered.
Winlaton.—Coal measures.

Tees District.

Population, 250,000. Geology, new red sandstone, magnesian limestone and millstone, grit, and carboniferous limestone; rainfall varies from 25 to 50, and averages 30 inches.

Barnard Castle.—Millstone grit; population, 4,500. Streams and private wells; a better supply being sought; spring at Railway rock cutting to hard.
Darlington. — Magnesian limestone; population, 27,729. From Tees.
Middlesbrough.—Keuper; population, 39,563.
Stockton.—Bunter; population, 30,000. By Stockton and Middlesbrough Water Company, from Tees above Darlington; polluted by Barnard Castle, Staindrop, Gainford, and other villages; 5,600 houses, 50 manufactories; 1,000,000 gallons daily for houses, do. for manufactories.

Wear District.

Population, 342,000. Geology, coal measures, millstone grit, and carboniferous limestone; rainfall varies from 35 to 50, and averages 30 inches.

Bishop Auckland.—Coal; population, 8,736. Shallow well, besides River Wear and tunnel running under it; 400,000 gallons daily; water of moderate hardness, but unsatisfactory in quality.
Durham.—Coal; population, 14,406.
Monkwearmouth.—Magnesian limestone.
Sunderland.—Magnesian limestone; population, 98,248. Deep wells in the dolomite; constant service; supply pure, but of rather high permanent hardness.
Stanhope.—Millstone grit.
Walsingham.—Carboniferous limestone.

Fen District.

In this district are included the Witham, Welland, Nene, and Ouse. Population, 1,332,000. Geology, lias, upper and lower oolite, chalk, and alluvium. Rainfall, from 20 to 25, averages about 23.

To consider the smaller river basins of the country would occupy too much space, and there does not appear so much need at present of forming them into districts. In conclusion, it is hoped that the prominence given to this subject by the exertions of the Society of Arts may result in the necessary legislation being undertaken, so that the national sources of water supply may be allotted to the districts establishing the best claim to them, floods and droughts may be better regulated, and, by the proper disposal and utilisation of sewage, the country may not find itself in the condition to which it is at present surely tending, viz.—

"Water, water, everywhere, but not a drop to drink."

Essay by W. H. Penning, F.G.S.

Motto—"Nemo."

Preliminary Considerations.

As all sources of water supply depend entirely upon physical conditions—the rainfall upon situation and elevation, the rivers upon physical features, and the springs upon geological characters —plans for division of the country should certainly be based upon its physical structure.

England and Wales fall naturally into three large, but unequal, sections, separated from each other by the great water-parting which divides the areas drained by rivers flowing towards the east, west, and south. These sections are divided by the main water-sheds into river-basins, and these are subdivided into smaller basins or valleys, each occupied by a tributary of the larger rivers. Such divisions are, of course, purely physical, although not in all cases well marked by physical boundaries, and the division of the country, for the purposes of water supply, into districts, each district consisting of some definite drainage area, would present a plan possessed of certain undoubted advantages. On the other hand, it would have its disadvantages, the two chief of which are, that the one-half of each district would be entirely cut off from the other by the river in its centre, and any works proposed for a supply of water, wholly or in part by gravitation, must be at or near its margin. If such a plan were adopted, two sets of works, belonging to two adjoining districts, would be in close proximity, and would involve, in some cases, an expenditure double that which would be sufficient for the works in question. In the following suggestions, the object kept in view is to utilise the advantages offered by the structure of the country, avoiding, amongst others, the two chief disadvantages referred to, of taking the river basins as

Map of Districts Proposed by W. H. Penning.

independent districts for the supply of water to the towns and villages within them.

The subject demands consideration under two headings:—1. Division of England and Wales into districts. 2. Mode of supply of pure water to the towns and villages in each district. It is treated as concisely as possible, consistent with making the suggestions clearly understood, and to the same end all details of areas, population, &c., have been given in tabular form in an appendix.

1.—Division of England and Wales into Districts.

It is suggested that England and Wales be permanently divided into twelve main sections, each one being separated from those adjoining by well

marked physical features. The proposed plan of division is exactly the reverse of that of river basins, the lines of separation being not the water-sheds, but the rivers. All the large and some of the smaller rivers, therefore, form the boundaries of these sections, which thus have low and comparatively level ground at their margin. They are traversed throughout a good part of their length by a central elevated line of water-shed, or, in some instances, by the main water-parting of the country. The surface waters of each section thus flow in two directions from the central lines, one portion going to the river of one basin, the other into that of the adjoining basin, or directly down to the sea. As rivers follow a definite course, the boundary of each section thus circumscribed is (with trifling exceptions) very clear, and in many respects is to be preferred to an arbitrary line, or to an irregular margin, such as is presented by a winding and frequently indistinct line of water-shed, which always varies with the contour of the higher and more broken tracts of country.

The accompanying map shows the proposed sections, lettered A to M respectively, their boundaries being described in Table I, Appendix, page 748.

Rivers frequently follow, for a considerable distance, a course corresponding, or nearly so, with geological lines of division; as examples may be mentioned the Trent and the Severn, near the junction of the Triassic and Liassic formations. The main lines of water-shed, on the other hand, frequently coincide for great distances, with geological escarpments, as the Chiltern Hills formed by that of the Chalk, and the Cotswolds by that of the Lower Oolites. Therefore, the sections having rivers for their boundaries, and main water-sheds for their longer axes, will include larger areas of similar geological structure than the river basins do, which, as a rule, have widely differing rocks on opposite sides, the Thames being the only noteworthy exception. As an example, Section H. may be mentioned, which is mainly bounded by the Thames and Ouse rivers, or by main branches from those rivers, and is traversed throughout its entire length, from Marlborough in Wiltshire to the north coast of Norfolk, by the chalk escarpment; and as the water supply of any area is dirctly dependent upon its geological phenomena, the water-bearing conditions, as well as those of a physical character, are more or less alike throughout each section.

The map, No. 3 (sent in with the paper), represents approximately the geological structure of the country, being divided, not strictly into geological formations, but with more regard to water-bearing characteristics. The colours, four in number, indicate the different classes into which the rocks may be conveniently divided :—

w. Pink.—Reliable water-bearing formations.

x. Neutral tint.—Uncertain rocks, which yield an abundance of water in some districts, and none whatever in others.

y. Blue.—Impervious clays, non-water-bearing, but generally with water-bearing beds beneath, and sometimes intercalated with them.

z. Grey.—Igneous, crystalline, and similar rocks which yield no water, and have no pervious beds beneath.

The sections, A to M, are proposed to be further divided into sixty-eight districts, upon a plan exactly similar to that suggested for the primary division. Each district is bounded by main tributaries of the rivers, and is traversed by one or more of the chief local water-sheds. The streams which flow into the main tributaries enclose still smaller areas, traversed by minor water-sheds at a relatively lower level, and such areas can, if it be found necessary or desirable, be formed into sub-districts upon exactly the same plan of sub-division. But the proposed districts only are shown on the map, any further division necessarily depending upon the strictly local geological structure and relative elevation.

The division of the sections, A to M, into districts is shown on map, the districts being figured according to the number in each section. The dotted lines indicate generally the main lines of water-shed and their chief branches only; the secondary and subordinate branch lines of water-shed being too numerous to be shown, without actual and detailed examination of the country for that purpose.

Particulars are given in Table II, page 749, in Appendix, of the size of each district, its population and average rainfall, in approximate numbers, London only being omitted. The London water supply is a matter demanding special investigation, and is beyond the "suggestions for supply to towns and villages." It may, however, be added that there is no very evident reason why the methods proposed should not, on a more detailed and extensive scale, be equally applicable to the supply of the metropolis.

Each section to be governed by a Board, consisting of representatives from each district within it, who shall have control over all matters of construction and expenditure by which the interests of the section, as a whole, are affected. For instance, by the order or sanction of this Board, the works of two or more districts may be wholly or partially united, where desirable, for the purpose of equalising supply; the cost of works in one district for the benefit of another may be fairly apportioned between them, and the reserve of water in all or any of them may be increased or diminished. Each district being complete in itself, is, as regards local matters, to be under separate and local management, subservient, however, as suggested above, to the central authority of its own section.

The chief points in favour of this plan for division into districts may be briefly summarised, as :—Definite physical boundaries; high ground in a central position; low ground at the margin; similarity of geological (therefore of water-bearing) structure. Each section and each district is accessible throughout, is independent of the others, and is capable of subdivision on the same plan, &c., &c. For distribution of water it will also be found convenient, as will be shown in the sequel.

The information conveyed by the maps, with the details given in the Appendix, although compiled from reliable sources, is intended to be approximate only, but it is sufficiently correct as a foundation for these suggestions. The accurate working out of details, physical and geological, upon which alone a final division of the country can be made, is a task far beyond the power of one individual during the time allowed. It must be undertaken systematically, if ever, by a staff of geological surveyors, well acquainted with the

phenomena of water supply, and might well form a branch of our National Geological Survey. The maps already published by that department would yield much assistance, and if supplemented by another examination of certain districts, from this special point of view, would leave little to be desired. Where the survey is still in progress, the water-bearing characters of the rocks might receive additional attention, and approximate heights of the water-sheds be collected at the same time. It is known that, in addition to their published works, the Government geologists have at command numerous notes, sections, and other valuable data, bearing upon this important question, and which would doubtless be readily forthcoming if required. The consequent works must be devised by engineers separately for each district, and founded upon the information thus obtained, considered in relation to their "wants and varying specialities."

2.—MODE OF SUPPLY OF PURE WATER TO THE TOWNS AND VILLAGES IN EACH DISTRICT.

The physical conditions are more or less different in each district; therefore, the sources and quantity of available water also vary, being wholly governed by those conditions. The physical features have, in addition, a direct and important bearing upon the methods of distributing the supply, in the quantity and manner best suited to the requirements of each locality. The two subjects, thus affected by the same influence, are intimately blended, both forming an essential part of the mode of supply; but they will, as far as practicable, be kept distinct and treated under two sub-headings:—

a. Source of supply, and *b.* Mode of distribution.

a.—SOURCES OF SUPPLY.

The phenomena of springs are now so well understood that a description of them need not be given here, but a few remarks may be made upon one or two points, in support of the suggestions which follow, and which are founded upon them.

It may be taken as a general rule that ridges and escarpments consist, wholly or in part, of water-bearing beds, such as limestone, chalk, or sandstone, and that the colter clays, being more readily denuded, occupy the lower grounds.

Strata generally dip towards and pass under the higher grounds; it is rarely they occur otherwise, and they are not often found quite horizontal. This is owing to the fact that the lie of the strata has, in a great measure, given to the ground its present form; in other words, anticlinals are more easily denuded than synclinals, the latter remaining whilst the former have yielded to denudation.

Case 1. Any set of pervious strata which occurs at the surface, as at *a a* in the diagram, will (as a rule) form a trough, and be found below the ridge, *R*, at a greater depth than is due to the difference in height of *a* and R. Water collected by these pervious beds upon their outcrop, *a a*, will rise in a boring made at R, through the impervious beds, *b b*, to a height corresponding (or nearly so) with that of their outcrop. Surface gravels are no exception to this general rule, and often occur in long hollows on elevated ridges, throwing out intermittent springs at the lowest points along their margin, *d d*. It is owing to the more rapid erosion of anticlinals that rivers and streams so frequently follow, at a greater or less distance, lines of geological boundary, a fact previously referred to, and of which advantage is taken in the proposed plan of division.

Case 2. The same pervious beds, *a a*, when dipping into the face of an escarpment, E, probably decrease in dip at a short distance beneath it, or even become horizontal, and they would be reached by a boring made on the top of the escarpment, E, at a depth not much below that of their outcrop, the water from them rising in the bore to an extent coinciding with the difference, whatever it may be.

Case 3. Where pervious beds, *c c*, in considerable thickness, overlie impervious beds, *b b*, and form an escarpment, E, or a ridge, R, the water-level within them rises beneath the higher grounds until the forces of hydrostatic pressure and frictional resistance are in equilibrium. Water will, therefore, be frequently found in borings commenced on a ridge, R, or escarpment, E, at a height very considerably above that of the lowest points of their nearest outcrop, *b b*, where the surplus water flows forth as perennial springs.

As strata dip towards the higher grounds, the water collected on slopes and in valleys flows underground in the same direction. Therefore, in river basins, where bounded by escarpments, the water collected in one basin flows towards and beneath another, but in districts as proposed, it is chiefly (although not invariably) available within its own area.

Water collected upon surface gravels, *d*, or other pervious beds similarly situated, and held up within them by impervious beds beneath, are available on ridges and escarpments by wells of moderate depth. The springs at the margin of such beds may also be utilised at a high level, and the water in nearly all such cases would be pure, as towns and villages are rarely found in these situations.

In the thick permeable beds, *c*, water is found at a moderate depth beneath the higher grounds, and in the pervious beds, *a*, at a greater depth, but in the latter case it will be nearer to the surface along the courses of lateral valleys.

The conditions illustrated in the diagram, of course, vary greatly, but the principle remains the same, and is utilised in the proposed methods of supply, as hereafter described.

An important phenomenon connected with questions of water supply here demands brief consideration. Strata that now throw out springs, or yield water when pierced, would, if occurring at a different level, or if inclined at a suitable angle, become the means of draining water away from other parts than that in which their waters are now collected. This follows as a matter of course, for the conditions would merely be reversed, and the water would pass through the beds in another direction, the springs of one locality being, in fact, but the natural drainage of another. Slight consideration renders evident the truth of the proposition that a well, capable of yielding a given quantity of water, is equally capable of getting rid of the same quantity by absorption. Water is not elastic, and when it bursts up from a penetrated rock, it does so not from the force of expansion, but from that of hydrostatic pressure.

And it rises to a certain height only, that of its present normal water-level; when this is attained in the well, and there is no outlet below that level, it rises no further. As it is pumped out, more water takes its place (if the pumping does not exceed the yield of the spring), but it never stands higher or falls lower than a definite point. Therefore, if water be put into the well, thus tending to increase the height above that point, the action is reversed, and the water so put in sinks down to the water-level at once, if its quantity does not exceed the yield of the spring. The rapidity with which water flows into a well depends directly upon the permeability of the strata through which it passes, and upon the same condition depends also the rapidity with which it can flow away from it; consequently, the spring is capable of yielding and of absorbing the same quantity of water.

Absorption wells may be employed with safety and advantage in getting rid of an excess of water from certain localities, in conveying it to others, and generally, on a give-and-take principle, in connection with water works, wells, and reservoirs.

It is beyond question that the total annual rainfall of England and Wales is, in every part, far in excess (in the ratio of about ten to one even in most unfavourable years) of what is actually required for a supply to the towns and villages, and is sufficient to keep the springs full from which its greater part is proposed to be drawn. But where no springs exist, either near the surface or at a great depth, the rain water or some other source must be utilised, if the vast cost of conveying water from one district to another at a great distance is to be avoided. The districts thus without, or comparatively bare of springs, are, however, those upon the older crystalline, metamorphic, and igneous rocks, from and beneath which but little, if any, water can be obtained. But it is on those non-water-bearing rocks that the "upland surface waters" are in their greatest purity, and if a sufficient quantity of that water can be stored in such districts to last over the dry periods, no better supply would be needed. These districts, owing to their situation, have a very large rainfall, unequally distributed throughout the year, the excessive fall of some months running rapidly away to the sea, leaving several dry months during which no sufficient natural source is available.

Generally speaking, such districts are thinly inhabited, the most populous areas being those upon rocks that are water-bearing; the supply of water from them having, doubtless, been one of the chief causes of the local growth of manufactures upon them, and the spread over their surface of a large population. A store of water to supply the districts in question might, therefore, be comparatively small; and in any district where it could not well be stored in sufficient quantity, that district will certainly be found, in other respects also, unsuited to the maintenance of a large community. In the rare cases where a supply can be had neither from springs nor by storage of rain-water, the streams and other present sources of supply must be relied on, possibly extended and certainly improved in regard to filtering arrangements.

In these suggestions, rivers and streams are not proposed to be utilised as sources of supply, except in the rare instances just mentioned, as their waters, being all more or less polluted, can only be rendered fit for drinking purposes (and this not in all cases), by an expensive process of filtration. But the head-waters of many rivers, where they exist as streams at a high level, and above the sources of contamination, may be safely used as an auxiliary supply of good water in such a position that it can be economically employed.

b.—Mode of Distribution.

The suggestions under this heading are of necessity brief, and of a very general character, details being purposely avoided. The latter can be of value only after a complete survey of each district, and when designed by an engineer, after a thorough consideration of all the ascertained facts of physical feature, geological structure, possible water supply, existing works, and special requirements. The general plan of each proposed method is described, but it is to be understood that these may be modified according to the nature of each district, and are not to be applied alike to all. In some districts all the modes may be adopted at a considerable saving of cost, while attaining the same results as if one plan only were adhered to throughout. Indeed, it is scarcely possible for it to be otherwise, as any one plan, applied in its integrity over a large and varied area, must be costly, and may or may not be effectual.

It is suggested that main lines of reservoirs, at a distance apart varying with the circumstances, be established along the chief water-shed, or water-sheds, of each district, the number and size of the reservoirs to be governed by the nature of the source whence each will be supplied. The available sources of pure water are of three kinds, and have been shown to be—

1. Shallow wells and surface springs.
2. Borings to deep-seated springs.
3. Surface collection of rain-water.

1. Drift gravels and other pervious strata occupy the higher grounds, and yield water at a moderate depth. Sites are to be selected upon, or rather near to, such beds where they occur on the main water-sheds, whether as ridges or escarpments. The reservoirs are there to be made to a depth below the lowest part of the pervious beds; a channel then cut longitudinally through the beds will tap their springs, which can be led directly into the reservoirs. Or the supply may, in some cases, be taken by pumping from shallow wells sunk in the beds, or by leading water into the reservoirs from the overflowing springs on their margin.

2. Reservoirs thus situated on the higher grounds are in an exceptionally good position for obtaining a supply of water from deep-seated springs, and borings there made down to each of the water-bearing formations beneath, would almost invariably ensure a good supply.

3. The reservoirs are, however, not always to be made on quite the highest points of the water-shed line; they may with advantage be situated, in cases where no surface springs exist, considerably to one side of it, thus being below its highest level. In this case, where there are no pervious surface deposits, all the rainfall on the ground above them can be readily collected as an auxiliary supply to that derived from the deep-seated

sources. Where there are neither deep nor surface springs, reservoirs of the main line may be at even a still lower level, on each side of the water-shed alternately, thus to collect rain-water from a larger area, generally of hard clean rocks, no supply, in such cases, being needed above them.

The main line reservoirs, when at the same level, and if not separated by too great an interval, are to be connected throughout the district by lines of pipes or open channels. When at different levels, they are still to be connected in the same way, but must then have intervening weirs and sluice-gates, or other appliances for regulating the flow from the higher to the lower reservoirs. When some of the reservoirs are very far apart from the others, those only in the same neighbourhood are to be connected with each other, thus forming two or more disconnected main lines in each district.

As the head waters of the rivers, rising from the higher grounds, flow towards each other to form united streams, branches from the main water-sheds run out towards the points of convergence. The more important of these main branches are to be occupied by reservoirs connected with each other and, if the conditions are favourable, also with the main lines, and supplied wholly or partly, as the case may be, by wells or by surface collections.

Similar lines of reservoirs to those on the water-sheds are to be formed on the flanks of the central elevation of each district, all those on the same side to be on, or about on, a level with each other. They will thus follow contour lines, touching the streams near their sources, and getting gradually away from them further down the valley. There may be one, two, or more of these secondary lines in each district according to the physical conditions, and the required supply, but there will be no subordinate branches. The diagram shows generally the position of the main and secondary lines of reservoirs as suggested.

The reservoirs on the secondary lines will be supplied by borings, when the conditions are especially favourable, by spring-heads and local surface springs (when pure), and by the surplus water from the main lines, but only in very exceptional cases are they to be filled by surface collection, and then no lines but those at the higher levels. As a rule, all are to be connected by pipes or open channels following the contours, but breaks may be made in the continuity of the connection, or even of levels, to suit the varying circumstances.

Reservoirs for storing rain-water in the barren upland districts can be well and cheaply made in such situations, by throwing strong dams across the smaller valleys (in colonial fashion). These valleys are usually steep-sided, and thus would form small, deep lakes, which for many months might retain, in good condition, large bodies of water, with a comparatively small surface exposed to evaporation.

Upon, or rather just above, the lowest ground in each district, a continuous line, partly of open, and partly of covered aqueducts, to be formed at descending levels, always sufficiently above and distant from the main stream, to supply the towns and villages situated near to, and about on a level with, the boundary. The aqueducts are to be continuous across the district, with weirs or sluice-gates at the changes of level; waste weirs are also to be provided at intervals, with channels to take the overflow into the stream or river. The water in the aqueducts is to be derived chiefly from the overflow of the main sources of supply on the higher grounds, supplemented by borings to deep-seated springs, especially to those which are known to overflow, and thus require no pumping.

The design and construction of the reservoirs, aqueducts, and works generally, are pure engineering matters, not to be entered on here; but a few brief remarks may be made upon the channels of connection, the mode of collecting surface waters, and underground distribution. It is suggested that, for economical reasons, the channels may be open at the top on the higher lands, where safe from chance of pollution. This may, in some cases, involve the cost of fencing, but this addition would probably be much more than balanced by the difference between that of open channels and of iron pipes. In some cases stone-ware pipes may be used cheaply and with advantage. Iron pipes will sometimes become a necessity, where low ground intervenes between two reservoirs that are to be connected, but in many cases level ground may be selected round the end of such depression, along which open channels may be constructed.

In all cases where these open channels are employed, they should be filled to the depth of a few inches with pebbles, or other uniformly coarse material, to prevent the growth of plants, and to promote the deposition of any suspended matter.

The rain-water would be collected, where necessary, in cross gutters or open ditches, intercepted by channels, following the contour lines; these would deliver the water first into a series of settling tanks (except in the barren upland districts), whence it would pass into the reservoirs which, in all cases, should be of sufficient depth to store a good portion of the storm waters.

The phenomena of absorption wells may be turned to account, in many instances, for increasing the yield of springs in one locality at the expense of those in another, where the supply is much in excess of what is required. There are many places in which the springs yield an almost unlimited quantity of water, which could be diverted into borings made down to another water-bearing formation. Each one of these borings would absorb as much as it would yield, and this absorbed water must, of necessity, go to feed other springs in the same formation, and which could be utilised elsewhere, sometimes within the same district, sometimes in those adjoining. In the latter case, the cost of making the absorption wells should be borne by the district thus benefited. In Table II absorption wells are mentioned in some of the districts where they may be adopted with advantage; but not by any means in all, as the existence of conditions favourable to their use must be (in all cases) determined by examination.

Water intended for absorption to remain awhile in the settling tank, or reservoir, to deposit its suspended matter, passing thence into the pipe leading to the bore-hole and standing up several feet above the floor of the tank, so as to prevent the entrance of sand and other material, by which the bore might be choked.

All overflow and surplus waters, from any source whatever, may thus be absorbed, so long as the streams are sufficiently full; but, when the streams are low, or falling, all surplus water must be allowed to pass into them by the overflow channels provided. Frequently, pervious beds outcrop along the flanks of hills and escarpments as at *a* in the diagram, and at a lower level in lateral valleys, when they can be used in a similar manner. By a simple process of heading the water back upon selected parts of their surface, it can be rapidly absorbed, and made to pass in to feed the springs beneath the higher ground.

CONCLUDING REMARKS.

An endeavour is made in these suggestions to effect, in almost every district, a combination, based upon the varying peculiarities of physical feature and geological structure, of two or more of the methods described in general terms; and to ensure by these means a reliable supply of wholesome water to the towns and villages, at the smallest possible cost consistent with that result, and with the establishment of works of a permanent character.

It will have been seen that the suggestions are founded upon the assumption that the largest supply of the purest water is to be obtained upon and beneath the highest grounds, and it is confidently believed that in a great majority of cases, a supply ample for the wants of a whole district may be derived from and beneath the water-bearing beds which occur in greatest number and most favourable circumstances beneath its water-shed. Where water is known to occur in abundance at lower levels it will, of course, be utilised also to reduce the cost of the works elsewhere. It is, therefore, proposed to establish the more important of the requisite works, reservoirs, pumping stations, &c., upon the main water-sheds of each district, the reservoirs being connected, and subordinate pumping stations at lower levels, when they may be found necessary or desirable. The main pumps to be constantly at work, to keep the connected reservoirs full to over-flowing, the overflow (which, however, need not be large) to be directed into the secondary reservoirs below or their connecting channels, which in turn will flow over into those (if any) at still lower levels, and those again into the low level aqueduct, whence it passes into the river.

By this plan of connecting the reservoirs, the supply will be equalised over a large area, and there will be a constant circulation of the water beyond that caused by the actual consumption; but the additional water for this purpose need not be obtained at the expense of the streams. It will come chiefly from deep wells, and storm-water stored at high levels, and as the overflow can, where necessary, be directed into the streams at various points along their course, it will more than compensate for what may be, in some cases, taken from them at their source. When the reservoirs and channels are once full, the quantity required will be only equal to that of the actual consumption, *plus* the small per-centage for the proposed method of circulation. This additional water, if found necessary for circulation beyond what is kept up by consumption, may be utilised as a motive power to aid in the pumping.

There will be no necessity for a large reserve of water, beyond the requirements of any area, such as must always be provided where works are independent of each other, for every reservoir acts as a reserve to the others, and each may be proportionately smaller, at a saving of cost without decrease of efficiency.

The main reservoirs being on the highest ground, all towns and villages can be supplied with water by gravitation. This is an important consideration from an economical point of view; for, admitting that the work, as a whole, involves a great outlay, it must still be far below that which would be required even for each town (to say nothing of villages) to provide pumping-stations and water-works of its own, in many of which water-towers and costly machinery would form necessary parts of the undertaking.

Each town and village would have a constant supply, taken by mains from the nearest reservoir or aqueduct at the proper elevation, the cost of such mains and local works being borne by the town and village, while that of the general works —pumping-stations, reservoirs, aqueducts, and channels—would be equally or otherwise fairly distributed over the entire district.

In Table II, page 749, particulars of each district are given, concerning its area, population, rainfall, geological structure, the water-bearing characters of its rocks, and (in general terms) the mode of supply to each based upon its physical conditions.

It may be added that a scheme of this kind could be carried out by degrees; if adopted for a small district, and there thoroughly tested, it might be gradually extended to other districts if the experiments were successful. All existing works might be utilised, dispensing with any polluted or doubted source of supply, and adopting those that are sketched out rather than described in these suggestions.

APPENDIX.

TABLE I.—SECTIONS—GEOLOGY AND BOUNDARIES.

Section A. On Carboniferous rocks.	N., Scotland; W., River Eden; E., North Sea; S., River Tees.
,, B. On Silurian rocks (Lake District).	N., Solway Firth; W., Irish Sea; E., River Eden; S., River Kent.
,, C. On Carboniferous, Trias, Lias, Oolites, and Chalk.	N., River Tees; W., River Kent; E., North Sea; S., Rivers Ayr and Humber.
,, D. On Carboniferous and Trias.	N., Rivers Ayr and Humber; W., Rivers Dee and Severn; E., River Trent; S., River Avon.

TABLE I.—(*Continued.*)

Section E. On Lias, lower Oolites and Oxford elay, some Chalk, and the Fenland.	N., River Humber; W., Rivers Dee and Avon; E., River Ouse and North Sea; S., Rivers Ouse and Thames.
,, F. On Silurian.	N. and W., Irish Sea; E., Rivers Dee and Severn; S., Rivers Treme, Wye, and Teame, and the Bristol Channel.
,, G. On Old Red and Carboniferous.	N., Rivers Treme, Wye, and Teame; W., Bristol Channel; E. and S., River Severn.
,, H. Cretaceous and Tertiaries.	N, River Ouse; E, North Sea; S, Rivers Kennet and Thames.
,, I. On Chalk and Tertiaries.	N., Rivers Thames and Kennet; W., Rivers Stour and Frome; E., English Channel; S., English Channel and River Medway.
,, K. On Wealden, Gault, and Upper Greensand.	N., River Medway; W., River Arun; E. and S., English Channel.
,, L. Continuation of Section E.	N., River Severn; W., Rivers Culm, Tene, and Ivel; E., Rivers Stour and Frome; S., English Channel.
,, M. Similar to Section G.	N., Bristol Channel; W., Atlantic Ocean; E., Rivers Culm, Tene, and Ivol; S., English Channel.

TABLE II.—DISTRICTS.

	Area in acres.*	Population.*	Average Rainfall in inches.†	Geological Formations.‡	Water-bearing or otherwise.‡	Mode of Supply; described generally in the "Suggestions."
A[1]	430,000	129,000	33	Carboniferous ... Igneous rocks ...	Uncertain. Non-water-bearing.	Two central disconnected main and branch lines of reservoirs, and secondary branch lines at lower levels; supplied partly by wells and partly by surface collection.
A[2]	430,000	129,000	35	Carboniferous ... Millstone grit ...	Uncertain. ,,	Main line and two branches on W. side, with branch lines at lower levels; partly by wells and partly by surface collection.
A[3]	543,000	140,000	43	Carboniferous ... Millstone grit ...	Uncertain. ,,	Two central disconnected main and two branch lines, with secondary branch lines; partly by surface collection.
A[4]	1,070,000	766,000	32	Bunter ... ... Carboniferous ... Millstone grit ...	Water-bearing. Uncertain. ,,	Three connected main lines, with secondary branches; chiefly by surface collection; the S.E. corner, by wells in bunter.
B	1,165,000	495,000	63	Silurian ... ... Carboniferous ... Bunter (small area only).	Non-water-bearing. Uncertain. Water-bearing.	Radiating main lines of reservoirs, with secondary branches; by surface collection. The extreme N. by auxiliary wells in bunter.
C[1]	663,000	920,500	50	Silurian ... ... Millstone grit ... Bunter	Non-wate-rbearing. Uncertain. Water-bearing.	Central main lines, and secondary branches; by surface collection, and by wells in bunter.
C[2]	490,000	365,000	32	Millstone grit ... Bunter ... ... Keuper ... ... Lias ... ... Oxford clay ... Lower Oolites ...	Uncertain. Water-bearing. Uncertain. Non-water-bearing. ,, Uncertain.	Two disconnected main lines, and secondary branches; chiefly by wells in and down to the bunter sandstone, and by surface collection. (Absorption well in bunter, for surplus surface water from the millstone grit.)
C[3]	446,000	346,000	28	Keuper ... ... Lias ... ... Oxford clay ... Lower Oolites ...	Uncertain. Non-water-bearing. ,, Uncertain.	Two disconnected main lines and secondary branches; chiefly by wells in lower Oolite.
C[4]	441,000	343,000	36	Millstone grit ... Magnesian limestone Bunter	Uncertain. ,, Water-bearing.	Two disconnected main lines, and secondary branches; chiefly by surface collection; on the E. by wells in bunter. (Absorption well.)
C[5]	550,000	555,000	50	Millstone grit ... Carboniferous ... Bunter	Uncertain. ,, Water-bearing.	Two disconnected main and two branch lines, and secondary branches; by surface collection; auxiliary wells on the E. in the bunter. (Absorption well between this district and D[2].)
C[6]	470,000	360,000	28	Bunter ... ... Keuper ... ... Neocomian... ... Lias ... ... Chalk ... ... Drift	Water-bearing. Uncertain. ,, Non-water-bearing. Water-bearing. ,,	Two disconnected main and one branch lines, and secondary branches; wells chiefly in chalk.
D[1]	525,000	1,230,000	43	Millstone grit ... Carboniferous ... Bunter	Uncertain. ,, Water-bearing.	One main and one branch line, and secondary branches; by wells and surface collection; auxiliary wells on S. and W. in bunter.
D[2]	631,000	761,000	32	Millstone grit ... Carboniferous ... Magnesian limestone Bunter	Uncertain. ,, ,, Water-bearing.	One main and two branch lines, and secondary branches; chiefly by surface collection; auxiliary wells on E. in bunter (Absorption well between this district and C[5].)
D[3]	637,000	445,000	36	Millstone grit ... Carboniferous ... Bunter ... ... Keuper	Uncertain. ,, Water-bearing. Uncertain.	One main and one branch line, and secondary branches; partly by wells, and partly by surface collection; auxiliary wells in bunter, on W.

* "Local Government Directory."
† Each inch of rainfall represents 100 tons of water per acre. Compiled from report of Rivers Pollution Commission.
‡ Report of Rivers Pollution Commission.

TABLE II.—(*Continued.*)

	Area in acres.*	Population.*	Average Rainfall in inches.+	Geological Formations.‡	Water-bearing or otherwise.‡	Mode of Supply; described generally in the "Suggestions."
D^4	894,000	433,000	27	Magnesian limestone Carboniferous ... Bunter ... ... Keuper	Uncertain. ,, Water-bearing. Uncertain.	One main and one branch line, and secondary branches; by wells chiefly in and down to bunter; by surface collection on the W. (Absorption well.)
D^5	720,000	650,000	33	Carboniferous ... Bunter ... ... Keuper	Uncertain. Water-bearing. Uncertain.	Two disconnected main lines, with three branches and secondary branches; chiefly by wells in and down to bunter.
D^6	769,000	473,000	32	Carboniferous ... Bunter ... ... Keuper	Uncertain. Water-bearing. Uncertain.	Main lines on N.E., with three branches and secondary branches; chiefly by wells in and down to bunter.
D^7	296,500	206,000	28	Keuper	,,	Main line and secondary branches; chiefly by surface collection.
D^8	620,000	632,500	38	Bunter ... ... Keuper	Water-bearing. Uncertain.	Main lines with one branch and secondary branches; chiefly by surface collection, auxiliary wells on N.W. in bunter.
E^1	477,000	258,500	35	Lias ... ... Oxford clay ... Lower Oolites ...	Non-water-bearing. ,, Uncertain.	Two connected main lines, with secondary branches; partly by wells in and down to lower Oolite, and partly by surface collection.
E^2	417,500	313,500	30	Lias ... ... Lower Oolites ...	Non-water-bearing. Uncertain.	By main lines, with two branches, and secondary branches; by wells in lower Oolite, and partly by surface collection.
E^3	674,000	270,000	25	Lias ... ... Oxford clay ... Lower Oolites ...	Non-water-bearing. ,, Uncertain.	Two disconnected main lines, and secondary branches; by wells in lower Oolite, and partly by surface collection.
E^4	827,000	468,000	25	Keuper ... ... Lias ... ... Lower Oolites ...	Uncertain. Non-water-bearing. Uncertain.	Two connected main lines, and secondary branches; by wells in lower Oolite, and partly by surface collection.
E^5	500,000	125,000	25	Neocomian... ... Lias ... ... Oxford clay ... Lower Oolites ...	Uncertain. Non-water-bearing. ,, Uncertain.	Two connected main lines, and secondary branches; by wells in lower Oolite, and partly by surface collection.
E^6	678,000	160,000	23	Neocomian... ... Chalk ... ... Drift	Uncertain. Water-bearing. ,,	Main line, with four branches, and secondary branches; by wells chiefly in and down to chalk.
E^7	590,000	163,000	20	Oxford clay and alluvium (forming the Fen land).	Non-water-bearing	Extension and improvement of the existing mode of supply.
F^1	123,000	35,000	55	Silurian	Non-water bearing.	Main line, and secondary branches; by surface collection.
F^2	688,000	155,000	60	Silurian	Non-water-bearing.	Three disconnected main lines with secondary branches; by surface collection.
F^3	472,000	152,500	35	Silurian ... ... Carboniferous ... Bunter	Non-water-bearing Uncertain Water-bearing.	Two disconnected main lines with secondary branches; chiefly by surface collection.
F^4	829,000	144,500	54	Silurian	Non-water-bearing	Main lines with two branches, and secondary branches; by surface collection.
F^5	628,000	220,500	33	Silurian ... ... Old red ... ... Keuper	Uncertain. ,, ,,	Two connected main lines, and secondary branches; by surface collection.
F^6	380,000	52,000	43	Silurian ... ... Old red	Non-water-bearing Uncertain.	Main line and secondary branches; by surface collection, and wells in old red sandstone.
F^7	636,000	178,000	60	Silurian ... ... Old red ... ... Carboniferous ...	Non-water-bearing Uncertain. ,,	Two connected main lines with one branch, and secondary branches; by surface collection, and wells in carboniferous and old red sandstone.
F^8	420,000	79,000	65	Silurian	Non-water-bearing.	Main line and secondary branches; by surface collection.
F^9	240,000	40,000	45	Silurian	Non-water-bearing.	Main line and secondary branches; by surface collection.
F^{10}	369,000	86,000	46	Carboniferous ...	Uncertain.	Main line, with two branches, and secondary branches; by surface collection.
G^1	405,000	330,000	45	Carboniferous ...	Uncertain.	Two connected main lines, and secondary branches; by wells in carboniferous, and partly by surface collection.
G^2	373,500	199,500	45	Old red ... ... Carboniferous ...	Uncertain. Uncertain.	Two connected main lines, and secondary branches; by wells in carboniferous and old red sandstone. &c
G^3	400,500	150,500	33	Old red	Uncertain.	Two disconnected main lines, and secondary branches; by wells in old red sandstone, and partly by surface collection.
G^4	485,000	241,000	28	Old red ... ... Keuper	Uncertain. ,,	Two disconnected main lines, and secondary branches; by wells in old red sandstone, and partly by surface collection.
H^1	594,000	224,000	30	Oxford clay ... Neocomian... ... Chalk	Non-water-bearing. Uncertain. Water-bearing.	Three connected main lines, and secondary branches; by wells in the chalk.
H^2	668,000	251,500	26	Neocomian... ... Oxford clay ... Lower Oolite	Uncertain. Non-water-bearing. Uncertain.	Three connected main lines, and secondary branches; by wells in lower greensand and lower Oolite.
H^3	403,000	156,500	25	Chalk ... ... London clay ...	Water-bearing Non-water-bearing	Two connected main lines, and secondary branches; by wells in the chalk.
H^4	375,000	325,000	25	Chalk ... ... London clay ...	Water-bearing. Non-water-bearing.	One main line and secondary branches; by wells in the chalk, and partly by surface collection.

* "Local Government Directory."
\+ Each inch of rainfall represents 100 tons of water per acre. Compiled from report of Rivers Pollution Commission.
‡ Report of Rivers Pollution Commission.

TABLE II.—(*Continued.*)

	Area in acres.*	Population.*	Average Rainfall in inches.†	Geological Formations.‡	Water-bearing or otherwise.‡	Mode of Supply; described generally in the "Suggestions."
H^5	631,000	264,000	23	Necomian ... Chalk ...	Uncertain. Water-bearing.	Three connected main lines and secondary branches; by wells in and down to the chalk.
H^6	487,000	220,000	23	London clay ...	Non-water-bearing (water-bearing beds beneath.)	One main line and secondary branches; by wells down to lower London tertiaries, and partly by surface collection.
H^7	408,000	84,000	23	Chalk ... London clay ...	Water-bearing. Non-water-bearing.	Two disconnected main lines and branches; by wells down to lower London tertiaries, and partly by surface collection.
H^8	622,000	220,000	22	Chalk (mostly covered by drift) ... London clay ...	Water-bearing. Non-water-bearing.	Two disconnected main lines, with one branch and secondary branches; by wells down to the chalk, and by surface collection.
H^9	488,000	183,000	23	Chalk (mostly covered by drift) ...	Water-bearing.	Two connected main lines and secondary branches; by wells down to the chalk, and by surface collection.
H^{10}	500,000	200,000	23	Chalk (mostly covered by drift) ...	Water-bearing.	One main line, with three branches and secondary branches; by wells down to the chalk, and by surface collection.
H^{11}	310,000	125,000	23	Chalk (mostly covered by drift) ...	Water-bearing.	Main line and secondary branches; by wells down to the chalk, and by surface collection.
I^1	679,000	210,000	35	Neocomian ... Chalk ... Eocene ...	Uncertain. Water-bearing. ,,	Two connected main lines, with one main branch and secondary branches; by wells in chalk, and in eocene beds on the S.
I^2	361,000	170,000	35	Chalk ... Eocene ...	Water-bearing. ,,	Three connected main lines and secondary branches; by wells in chalk, and in eocene beds on the S.
I^3	402,000	206,000	30	Chalk ... London clay ... Bagshot ...	Water-bearing. Non-water-bearing. Water-bearing.	Main lines and secondary branches; by wells in the chalk; in Bagshot beds on the N.
I^4	804,000	413,000	35	Neocomian ... Chalk ... Eocene ...	Uncertain. Water-bearing. ,,	By two connected main lines, with three branches and secondary branches; by wells in the chalk and lower greensand.
I^5	549,500	557,000	30	Neocomian ... Chalk ... Weald clay ... London clay ...	Uncertain. Water-bearing. Non-water-bearing. ,,	Three main lines and secondary branches; by wells in chalk and lower greensand.
I^6	487,000	426,000	32	Neocomian ... Chalk ... London clay ...	Uncertain. Water-bearing. Non-water-bearing.	Main lines, with three branches and secondary branches; by wells in the chalk and lower greensand.
I^7	93,000	66,000	35	Wealden ... Cretaceous ... Eocene ...	Uncertain. ,, Water-bearing.	Main line and secondary branches; by wells and surface collection.
K^1	320,000	150,000	34	Hastings beds. ... Neocomian ... Weald clay ... Chalk ...	Water-bearing. Uncertain. Non-water-bearing. Water-bearing.	Four connected main lines and secondary branches; by wells in the chalk, lower greensand, and Hastings beds.
K^2	558,500	348,000	33	Hastings beds ... Neocomian ... Weald clay ... Chalk ...	Water-bearing. Uncertain. Non-water-bearing. Water-bearing.	Main line and secondary branches; by wells in the Hastings beds, and on the S. in chalk and lower greensand.
L^1	300,000	184,000	33	Oxford clay ... Lias ... Lower Oolites ...	Non-water-bearing. ,, Uncertain.	Three main lines and secondary branches; partly by wells in and down to lower Oolite, and partly by surface collection.
L^2	500,000	250,000	29	Bunter ... Oxford clay ... Lias ... Lower Oolites ...	Water-bearing. Non-water-bearing. ,, Uncertain.	Main line with secondary branches; partly by wells in and down to lower Oolites, and partly by surface collection; auxiliary wells in bunter on W.
L^3	450,000	185,000	36	Bunter ... Lias ... Lower Oolites ...	Water-bearing. Non-water-bearing. Uncertain.	Two connected main lines, and secondary branches; by wells in lower Oolite on E., and bunter on W., partly by surface collection.
L^4	450,000	142,000	36	Oxford clay ... Chalk ... Eocene ...	Non-water-bearing. Water-bearing. ,,	Three connected main lines and secondary branches; by wells in the chalk and eocene beds.
M^1	882,000	356,000	48	Igneous ... Old red ... Millstone grit ...	Non-water-bearing. Uncertain. ,,	Main line and secondary branches; chiefly by surface collection.
M^2	542,000	206,000	52	Igneous ... Old red ... Millstone grit ...	Non-water-bearing. Uncertain. ,,	Main line and secondary branches; chiefly by surface collection; auxiliary wells in millstone grit.
M^3	800,000	240,000	58	Igneous ... Old red ... Millstone grit ...	Non-water-bearing. Uncertain. ,,	Three main lines with two branches and secondary branches; chiefly by surface collection; auxiliary wells in old red sandstone.
M^4	403,000	181,000	35	Old red ... Bunter ...	Uncertain. Water-bearing.	Two disconnected main lines and secondary branches; by wells in bunter, and by surface collection.

* "Local Government Directory."
† Each inch of rainfall represents 100 tons of water per acre. Compiled from report of Rivers Pollution Commission.
‡ Report of Rivers Pollution Commission.

Among the Bills abandoned for the Session by the Government is the Bill for Amending the Law of Letters Patent for Inventions. It need not be said this fate has long been anticipated for the Bill, which only follows its predecessors of 1876 and 1877.

The American *Plumber and Sanitary Engineer* suggests to life insurance companies that, instead of merely sounding persons to discover tendency to disease, it would be well for medical examiners to inquire respecting cesspools leaking into wells, or untrapped pipes beneath basins and closets?

MISCELLANEOUS.

NATIONAL TRAINING SCHOOL FOR MUSIC.

The second general report of the School, dated Easter, 1879, has just been issued, and is as follows:—

The Committee of Management have the honour to submit for the information of the founders of scholarships, and their patrons generally, the following brief report on the condition and proceedings of the school during the interval which has elapsed since the period of the publication of the first report, viz., Christmas, 1876:—

Scholarships.—The body of scholars has been increased by 11, and now numbers 90, viz.:—22 males and 68 females. Of these additional scholars, two are from Birmingham, two from Liverpool, two from Northumberland, one from members of the Society of Arts, one from Bradford, one from Bristol, one from Lord Frederick Fitzroy, and one from Messrs. Novello and Co. Since the publication of the last report, 11 scholars have resigned their scholarships. New scholars have been elected by the founders to fill ten of the vacancies thus created; and there is still one vacancy.

Attendance, Conduct, and Studies of the Scholars.—The attendance of the scholars, save in cases of sickness, continues to be regular and punctual, and their general behaviour is very satisfactory. The instruments and subjects of study are, of course, substantially the same as they were at the time of the issue of the first report. At present, 51 scholars are cultivating the piano as their principal subject of study; 27, singing; 10, the violin; and two, the organ. The pianists take singing, violin, organ, or violoncello for their second studies; while the vocalists, violinists, and organists are compelled to study the piano. All the scholars continue to attend the harmony and solfeggio classes, and ten of them have from one to two hours a week tuition in counterpoint and composition. During certain terms there are fortnightly performances, in which all the scholars in turn take part.

Terms of Study, and Examinations.—The period covered by the present report includes seven school terms, viz.:—The Easter, Midsummer, and Michaelmas Terms of 1877 and 1878, and the Easter Term of 1879. At the end of the Easter Term, 1877, the first annual examination of the students took place. It was conducted by the Principal (Dr. Arthur Sullivan), who was assisted by Dr. Stainer, Mr. Pauer, Mr. Visetti, and Mr. Carrodus; and was attended on the part of the professional examiners by Sir Michael Costa, Sir Julius Benedict, and Professor Ella. The results of the examination were considered to be most satisfactory. The second annual examination was held on Monday and Tuesday, the first and second days of July, 1878. It was conducted by the Principal and the Board of principal Professors, and was attended, on the part of the Professional Examiners, by Sir Julius Benedict, Sir George Elvey, Mr. Charles Hallé, Dr. John Hullah, and Professor Ella. The Midsummer Term of 1877, and the Easter Term of 1878, concluded with the ordinary Terminal Examinations, which were conducted by the Principal and the Board of Professors. Touching these Examinations, the Principal reports:—"Every pupil was thoroughly examined in every branch of study, and, on the whole, the result of the work done in the school has been highly satisfactory. This result has been owing alike to the excellent spirit shown by the students, and to the zeal and energy displayed by the staff of professors, and the great interest shown by them in the well-doing of their pupils individually. In the early history of an institution of this kind, it cannot be expected that those who are most interested in its permanent and practical welfare will commit themselves to any positive opinion as to the ultimate result of an effort which still partakes of the nature of an experiment. But it is most satisfactory to make the progress which has already, in the third year of the school's existence, taken place in all departments. And the result of this year's work (1878), as compared with those of the last year (1877), point very hopefully to a further and sure advance for the time to come."

Donations and Loans.—Generous and appropriate donations of framed engravings on musical subjects, and of great musical composers, have been made to the school by H.R.H. the Duke of Edinburgh, K.G., and by Mr. Ernst Pauer. Valuable gifts of printed and manuscript music have been made to the library by Messrs. Novello and Co., Mrs. Freake, and Sir Wm. G. Anderson, K.C.B. The Count Gio. Battista Rossi Scotti, of Perugia, Italy, has also most courteously and considerately presented to the school an autograph score of Morlacchi's opera, "La Gioventu di Enrico V.," in 2 vols., together with a printed copy of the "Life and Works" of Morlacchi, by himself. The houses of Messrs. Collard and Collard and Messrs. Kirkman and Sons have each lent an additional grand pianoforte to the school, thereby greatly increasing our facilities both for the instruction of the students, and for giving the fortnightly performances. Mr. Henry Leslie has also most kindly expressed his readiness to lend to the school at any time the vocal and instrumental parts of such concerted music as may be required for the studies and practice of the scholars.

Efforts to Augment the Educational Facilities of the School.—With a view to the acquirement of means of extending the education now being given to the scholars so as to increase its efficiency, a memorial setting forth the history, objects, resources, management, and present condition of the school, has been presented to her Majesty's Commissioners of the Exhibition of 1851—upon whose estates the school buildings have been erected, and who already generously give the site of the premises rent free—praying them out of the vast funds entrusted to them for the encouragement of arts and sciences, to confer on this school such an annual endowment in money as would enable the Committee of Management to appoint Professors of Modern Languages, to subsidise eminent performers to take leading parts in the orchestra, to engage lecturers on musical physics, and to establish classes for dramatic instruction. The reply of her Majesty's Commissioners is to the effect that, if the school could be united with the Royal Academy of Music, to form together the nucleus of a large institution, which could be placed on a more permanent and extensive basis than any existing institution of the kind, such institution would fall more directly within the scope of the operations of her Majesty's Commissioners, and might look to them for substantial help.

(Signed) ALFRED, *President.*

NOTICES.

NOTICE TO MEMBERS.

Members are reminded that the Midsummer Subscriptions are now due. Cheques and Post-office Orders should be made payable to the order of "H. T. Wood," and crossed "Coutts and Co."

SANITARY CONFERENCE.

The Pamphlet containing a full report of the papers and proceedings of the late Conference on National Water Supply, Disposal of Sewage, and Health, will be ready in a few days, price 2s. 6d.

Applications for copies of the Report should be addressed to the Secretary.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,392. Vol. XXVII.

FRIDAY, JULY 25, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

LE NEVE FOSTER TESTIMONIAL FUND.

The following is a complete statement of the subscriptions received for the Le Neve Foster Testimonial. It has been audited by the Society's Auditor, and a cheque for £1,853 11s., the amount of the subscriptions after the expenses had been deducted, has been handed to Mrs. Le Neve Foster:—

Dr.	£	s.	d.	£	s.	d.
To Subscriptions promised..	1,944	13	0			
,, ,, unpaid at this date	18	18	6			
,, ,, received ..				1,925	14	6
,, Interest received on amount placed to deposit account during collection of Fund				11	10	8
				£1,937	5	2

Cr.	£	s.	d.	£	s.	d.
By Expenses:—						
,, Postage	41	8	2			
,, Addressing wrappers and envelopes	2	10	0			
,, Printing	36	4	0			
,, Advertising	3	12	0			
,, Balance in Banker's hands	1,853	11	0			
				1,937	5	2

Examined and found correct.
(Signed) J. O. Chadwick,
Auditor,
Society of Arts.

London, July 16th, 1879.

ARTISAN REPORTERS AT THE PARIS EXHIBITION, 1878.

The following is the report of the Joint Committee of the Royal Commission for the Paris Exhibition and the Society of Arts, to his Royal Highness the Prince of Wales, K.G.:—

Sir,—In April, 1878, a letter was addressed by your Royal Highness, as President of the Royal Commission for the Paris Exhibition, to the Council of the Society of Arts, asking the Society to undertake the duty of sending a number of selected artisans to Paris, with a view to the preparation of reports on the Exhibition, similar in character to those which had been issued, through the agency of the Society, in connection with the previous Exhibition of 1867. Your Royal Highness added that you proposed to nominate a Committee from among the members of the Royal Commission to co-operate with the Council in the matter, and intimated your intention of subscribing to the fund which would be required for the purpose of carrying your wishes into effect.

In reply, the Council of the Society expressed the readiness with which they would endeavour to carry out your Royal Highness's proposal, and proceeded to appoint a Committee to act in union with the Committee of the Royal Commissioners.

The Joint Committee thus formed consisted of the following members:—

Committee of Her Majesty's Commissioners.—The Earl Spencer, K.G.; the Right Hon. Lyon Playfair, C.B., F.R.S., M.P.; Mr. Sampson S. Lloyd, M.P.; Mr. Hugh Birley, M.P.; Mr. Joseph Chamberlain, M.P.; Mr. Samuel Morley, M.P.; Mr. John Mulholland, M.P.; and Mr. Anthony J. Mundella, M.P.

Committee of the Society of Arts.—Mr. William Hawes, F.G.S., Deputy Chairman of the Council; Lieut.-Colonel Donnelly, R.E.; Mr. Henry Doulton; Mr. H. Reader Lack, Treasurer of the Society; Mr. R. Rawlinson, C.B.; Admiral Sir Erasmus Ommanney, C.B., F.R.S.; and Mr. W. H. Perkin, F.R.S.

Secretary.—Mr. P. Le Neve Foster.

Assistant-Secretary.—Mr. H. T. Wood.

The Joint Committee held their first meeting on the 16th May, when the following were appointed as a Sub-Committee to carry out the arrangements:—Mr. S. Morley, M.P.; Mr. W. Hawes, F.G.S.; Mr. Henry Doulton; with Earl Spencer as Chairman.

The principal steps decided on at this meeting, and at the meetings of the Sub-Committee held during the same month, were:—

1. The opening of a subscription list.
2. Entering into communication with the chief employers of labour in the London trades represented in the Exhibition, and with representatives of artisans employed in London trades.
3. Opening a correspondence with the Mayors and Chambers of Commerce of the chief seats of industry in the Kingdom.

In accordance with these instructions, the Secretary communicated with the Mayors or with the Chairmen of the Chambers of Commerce of 54 towns.

The Sub-Committee also met a number of employers connected with the metropolitan trades, and discussed with them the best means of selecting the artisans.

They further met a Committee of London artisans, and obtained from them a list of workmen whom they considered qualified to represent a number of the London trades.

The Joint Committee wish to state to your Royal Highness that they received great assistance from those who attended both these meetings.

By these means a list of names was obtained, to which was added a further number of applications from artisans anxious to be selected.

The list was carefully considered by the Sub-Committee, and afterwards by the Secretaries acting under their instructions.

The Sub-Committee also made arrangements for the journey of the men to Paris. Each reporter was furnished with a route card and a railway card. The latter was exchangeable on payment of the special fare, £1, for a return ticket to Paris on any of the three lines, London Chatham and Dover Railway, South Eastern Railway, and London Brighton and South Coast Railway. The route card, on presentation at the offices of the British Commission, entitled the owner to a free pass to the Exhibition, and also to board and lodging at a certain special rate. The reporters generally travelled in parties; for, though it was left to the men to choose their own days, and their own routes, it was found that almost all preferred to make the journey in company with others; some few, however, went over singly. As far as was possible, notice of the approximate number in each party was sent over a few days beforehand to the Secretary to the British Commission.

For the accommodation of the men, two houses were rented in the immediate neighbourhood of the Champ de Mars, and, in addition to these, rooms were set aside for the same purpose in one of the houses rented for the staff of the Royal Commission.

The internal arrangements of these premises were closely controlled by Sir Philip Cunliffe Owen. All the rooms available were continuously full, and in them were quartered not only the delegate reporters and visiting parties of artisans, but most of the English workmen permanently engaged in the service of the various exhibitors.

Sir Philip Owen reports that the conduct of the English artisans thus provided for was, through the whole period, exemplary; and that their sense of the benefit afforded them by the arrangements made has, in every case, been expressed in warm addresses of thanks to Sir Philip Owen, and to the police officers and others who had the charge of the arrangements for the comfort of the men during their stay.

Each party, on its arrival, was met at the railway station by some of the police staff of the Commission, and was conducted immediately to the Workmen's-hall. Provisions suitable to their English habits were provided for the men at a moderate tariff, by which the whole expense of each man amounted to about 45 francs a week. That the men were satisfied with the accommodation provided is shown by the fact, that instances of their preferring to cater for themselves outside were extremely rare.

Tickets of admission to the Exhibition, and copies of the official catalogues of the British Section (including the technical treatises contained in the second part) were given to each party as it arrived.

Sir Philip Owen then received each party of delegates at your Royal Highness's pavilion in the Rue des Nations, and explained to them his views of their responsibility in the task they had undertaken. He also ascertained from each man his own views in return of the assistance that would be most useful to him in the prosecution of the task. Upon these explanations, Sir Philip Owen furnished the men with letters of introduction to the firms engaged in their respective industries, and these obtained admission for them to the best workshops and works within reach.

The committee feel that their warm gratitude is due to the French firms, who thus, without any thought of jealousy or reserve, threw open their works to the inspection of foreigners. Hence the international gathering became still further instrumental in drawing closely together the workers of the two great nations alike interested in the promotion of Arts and Manufactures.

The men were always accompanied on their visits by a member of the staff of the Royal Commission, whose duty it became to interpret for them where necessary, and generally to guide and assist them.

The delegates have, in all cases, expressed their full satisfaction with the manner in which this somewhat difficult duty was performed by the gentlemen selected for it.

The opportunities of intercourse afforded them in their frequent visits to the Workmen's Exhibition and to the workshops, resulted in many cases in intimacies, which led to the introduction of some of the English artisans to the social life of the better sort of French workmen.

The first party of the Society of Arts' Reporters started about the middle of August, though they had been preceded by some other parties of artisans sent over by their employers, independently of the Society's arrangements. The men continued to go over regularly until about the end of October.

In all, 207 tickets were issued by the Committee. Three were returned, leaving 204 as the number of artisans sent through the agency of the Committee. Of these, 57 were sent at the expense of the fund. The charges of the other 147 were defrayed as follows:—

Sent by Towns.		
Leicester	3	
Exeter	1	
Sheffield	20	
Dublin	24	
Leeds	6	
Edinburgh	12	
Bristol	9	
Huddersfield	5	
Liverpool	10	
Total		90
Sent by Companies and Societies.		
Coachmakers' Company	5	
Builders' Society, London	6	
Total		11
Sent by Employers.		
Hooper and Co., coachmakers	24	
Thrupp and Maberly, ,,	9	
Peters and Sons, coachmakers	3	
Macfie and Co., sugar refiners	3	
Total		39
Paid their own Expenses		7
Total		147

The Joint Committee did not consider it necessary to require all the artisans sent out through the agency of the Society of Arts to furnish reports, but all those whose expenses were paid from the fund subscribed undertook to do so. In all, 168 reports have been received.

Of these 168 reports, those from Liverpool (10), Huddersfield (5), Bristol (9), Leeds (6), and Leicester (3), have been printed by the towns; and the five reports by the Coachmakers' Company's reporters have also been printed by a late Master of the Company, Mr. C. Saunderson.

The Committee think it most desirable that whatever reports are published, should be issued in such a form as to enable them to be widely distributed amongst the artisans of the various classes of industries to which they refer.

They have carefully considered the best way of accomplishing this object, and they are glad to be able to state to your Royal Highness that they have succeeded in making an arrangement with Messrs. Sampson Low, Marston, Searle, and Rivington, to publish the best of the reports in parts as well as in a complete volume.

Messrs. Eyre and Spottiswoode have most liberally undertaken to print the reports at cost price, and Messrs. Sampson Low, Marston, Searle, and Rivington, with equal liberality, have expressed their readiness to take any further risk connected with the publication, provided they are relieved from the cost of printing.

The Committee consider that the offer of these firms is a most advantageous one, and have, therefore, not hesitated to accept it.

They have not considered it desirable (nor if they had wished it, would the funds at their disposal have permitted) that all the reports received should be published; they have, therefore, made a selection of the best reports, and these they have had carefully edited.

The work of editing they have entrusted to Mr. H. Trueman Wood, the Secretary of the Society of Arts, and Dr. R. J. Mann. The Committee think it very important to preserve the distinguishing characteristics of each report, and they have, therefore, instructed the editors only to omit such portions of each report as may be redundant, from repetition or from irrelevancy, and to be very careful not to make more alterations than may be required in order to correct orthographical and grammatical errors, and to remove confusion and obscurity of expression, such as naturally occur in the work of men unaccustomed to writing.

The twelve classes under which it is proposed to arrange the reports, as nearly as circumstances permit, are as follows:—

I.—Pottery.
II.—Glass.
III.—Art-Work.
IV.—Mechanical Engineering.
V.—Watchmaking and Jewellery.
VI.—Building.
VII.—Cabinet Work.
VIII.—Mining and Metallurgy.
IX.—Horticulture and Agriculture.
X.—Printing.
XI.—Textile Fabrics.
XII.—Leather and India-rubber.

Each part will be published in a neat wrapper at the price of sixpence. The complete series will also be published in one volume, strongly bound, for reference, at a cost of 7s. 6d. With the complete volume, the Committee hope to be able to add as a frontispiece a portrait of your Royal Highness, the President of the British Commission.

The Committee cannot conclude their report to your Royal Highness without expressing their sense of the services rendered by their late Secretary, Mr. P. Le Neve Foster, and their regret at his most sudden death. They also wish to state that they received most efficient aid from Sir Philip Cunliffe Owen, K.C.M.G., C.B., who gave to this, as to every other detail of the great Exhibition, his close personal attention. The Committee feel that, without his cordial and zealous aid, they would have been unable to provide the organisation requisite to carry out successfully the arrangements for the reception and entertainment of the reporters at Paris.

The Committee believe that little remains to complete the task which your Royal Highness entrusted to them, and, with your Royal Highness's permission, they propose now to leave to the Council of the Society of Arts, who are ready to undertake the duty, any business which may yet remain to be settled.

Spencer,
Chairman.

CANTOR LECTURES.

DWELLING-HOUSES: THEIR SANITARY CONSTRUCTION AND ARRANGEMENTS.

By Prof. W. H. Corfield, M.A. M.D. (Oxon).

Lecture II.—Delivered February 24, 1879.

Ventilation, Lighting, and Warming.

The air in our houses is rendered impure in various ways, but chiefly by our respiration, and by the products of combustion that are allowed to escape into it from lights and fires. The air that we expire contains a certain quantity of foul, or putrescent, organic matter. It is charged with moisture, and contains about five per cent. less oxygen and nearly five per cent. more carbonic acid than the air that we inspire. It is neither the diminution of oxygen nor the increase of carbonic acid in the air of rooms that is of the greatest importance to living beings, but the accumulation of foul organic matter and the excess of moisture. It is this which renders such atmospheres stuffy, and not the diminution of oxygen or the increase of carbonic acid, which are so slight as to be of little importance, even in overcrowded rooms. Nevertheless, since the increase in carbonic acid is proportional to the increase in other impurities, and since we can estimate very accurately the amount of carbonic acid in the air, the increase of carbonic acid is taken as an index of the impurity of the atmosphere. The average amount of carbonic acid in the outer air is four parts in ten thousand. Professor De Chaumont found by his experiments that, whenever the amount of carbonic acid in the air of a room exceeded the amount in the outer air by more than two parts per 10,000, the air of the room was not fresh, that is, say, that the foul organic matter in it and the excess of moisture were sufficient to make the room stuffy. Hence,

two parts of carbonic acid per 10,000 of air, over and above that in the outer air, are taken as the limit of respiratory impurity. As an adult breathes out, on the average, six cubic feet of carbonic acid in ten hours, it is clear that, in order that the air of the room in which he is may be kept fresh, he must have 30,000 cubic feet of air in the 10 hours, or 3,000 per hour. In this climate we cannot change the air of a room more than three or four times per hour without causing draught, and so each person ought to have from a thousand to 750 cubic feet of space, the air of which should be changed three or four times per hour respectively. The way in which this space is arranged is also a matter of some importance. For instance, the air above a certain height is of little use for purposes of ventilation if combined with too small a floor space. To take an extreme case—a man standing on a square foot of ground, with walls 3,000 feet high all round him, would be in 3,000 cubic feet of space; but it is quite obvious that he could not live in it. But, even without any enclosure at all, and without any limit as to height, it is not difficult to conceive a place overcrowded. For instance, all the inhabitants in the world, men, women, and children, could stand upon the Isle of Wight; but it is quite certain that they could not live there, even if it were only for the want of air. So it is usual, in estimating cubic space, to disregard the height above 11 or 12 feet. It is also obviously of importance that the floor space should be properly distributed; but, about this, so far as dwelling-houses are concerned, there is no need to enter into particulars. We are not able to insist on anything like 1,000 or 750 cubic feet of space in all instances, and amounts varying down to as low as 300 cubic feet per individual are adopted. In the case of a family living in one room, which is so small as to afford less than 300 cubic feet per individual, it is usual to consider that the limit of overcrowding which should be allowed by law has been reached. We cannot have, as a general rule, rooms so large that the air does not require changing while we are in them. Thus, for instance, a person in a bedroom for seven hours consecutively requires about 21,000 cubic feet of air if the atmosphere is to be kept fresh. Supposing him to have this without change of air, he would require a room, say, 70 feet long by 30 wide and 10 high. This makes it quite clear that in rooms such as we have there must be a change of air.

In studying ventilation from a practical point of view, the chief agents that we have to consider are the winds, and movements produced in the air by variations in its density, usually brought about by variations in its temperature; the property of the diffusion of gases by means of which the air is brought to a uniform composition when the temperature is the same throughout, being one which, practically speaking, does not affect the question much. With artificial methods of ventilation, in which the air is forced in a certain direction by machinery, we have little to do, as few of them are suitable for use in dwelling-houses. The wind, as an agent of ventilation, is powerful, but its disadvantage is that its action is irregular. When all windows and doors can be opened, a current of air which may be imperceptible, is quite sufficient to change the air of a house in a very short time, and houses that have windows on both sides are for this reason much more healthy than houses built back to back, which can never have through ventilation. This is the direct action of the wind, which may generally be utilised in large rooms with windows on opposite sides, like school-rooms, by opening that which is nearest to the direction from which the wind comes, a little way at the top, and also opening the one which is diagonally opposite to it at the top a little further than the first one. The direct action of the wind has also been utilised for ventilating large houses by Silvester's plan, which consists in having a large cowl, that always faces the wind, at the top of a pipe leading down into cellars in the basement of the house, where the air can be warmed by stoves, and allowed to ascend into the house. By this plan the holds of ships are frequently ventilated. But the aspirating action of the wind is, perhaps, of greater importance. When the wind blows over the top of a chimney, or over a ventilating pipe, it causes a diminution of pressure of the column of air in the chimney or ventilator, and so produces an up-current, upon precisely the same principle that little bottles made for distributing scent about apartments act. For this reason, it is, as was hinted in the last lecture, important that chimneys should be higher than the surrounding buildings, so that any wind that blows may cause or increase an up-draught in them. In this way not only is smoke prevented from ascending into the rooms, but the amount of air carried through rooms up the chimneys is increased, and the ventilation of the house improved. There being, then, in every house, and frequently in every room, a shaft—whether sufficient or not, we will consider by-and-bye—for the escape of air, it becomes of the first importance for us to consider the means by which air may be admitted into our houses and into our rooms. In summer, and whenever the air is as warm outside the house as inside of it, there is no difficulty about this. We have only to open the windows—wind-doors, remembering the proverb that "Windows were made to open and doors to shut"—on both sides of the house, and the air is generally changed fast enough, but it is in winter, when the air is colder outside the house than inside, that the difficulties arise, and so in speaking of ventilation I shall always assume that the air outside the house is colder, and therefore heavier, and exercises greater pressure than the air inside it. This being the case, it follows that if we open a window, or make an aperture through a wall into the outer air, or through the wall of a room into a passage, or staircase, in which the air is colder than it is in the room, air will come in. In fact, a room under these conditions may be looked upon as if it had water outside of it, and it is quite apparent that, in such a case, if you bored a hole through the wall into the water on the other side, water would come in, and the air of the room would escape by the chimney. This is precisely what happens with the cold air outside. If no special opening is provided through which the cold air can come into a room, it enters by such openings as there are; by the apertures between the sashes of the windows, by the—perhaps fortunately—badly-fitting doors, crevices in

the floors, walls, and cupboards, through the walls themselves, as has been shown by Pettenkofer, and sometimes down the chimney. If, then, air will come in through an aperture placed in any position, it becomes necessary to consider where apertures should be placed, and what precautions are necessary with regard to them. Theoretically, the admission of pure air should be at the lowest part of the room, and the extraction of the vitiated air, which is warm, at the upper part of the room; but practically the outer air cannot be admitted without certain precautions at the lower part of the room by mere apertures, as everybody knows who has been accustomed to sit in a room when a draught comes under the door. On the other hand, if an aperture is made into the outer air through a wall at a few feet from the floor, the air enters in a cold straight current for some distance into the room. If the aperture be higher up, it comes in and falls, just as water would do, on to people's heads, somewhere about the middle of the room. So it is quite clear that certain precautions are necessary in the admission of air so as to prevent draughts. Since we have, or ought to have, windows in all rooms, it will be convenient to consider, first, the ways in which they may be utilised for the admission of air. We cannot simply open a sash window at the top or bottom in cold weather without feeling a draught, but there are several ways in which this difficulty may be got over. The simplest is by placing a board of wood underneath the lower sash, as suggested by Dr. Hinckes Bird, whose original model I have here. This board is sometimes now made with a hinge in the middle, so that it can be got in and out more easily; or the board, instead of being placed under the lower sash, may be placed across, from side to side, in front of the lower part of the lower sash, so that the lower sash may be opened to a certain height without any air coming in below it. These boards may be covered with green baize, or some other suitable material, so as more perfectly to prevent the entrance of the air at the lower part of the window. In either case, the bars of the sashes at the middle of the window are no longer in contact, and air comes in at the middle of the window, between the two sashes, taking an upward direction, in the form of a fountain, and producing no draught. This shows us the direction in which cold air ought to be admitted into a room—after the fashion of a fountain, in which it can be readily obtained, owing to its greater pressure, and not after the fashion of a waterfall.

This simple plan, which I recommend very strongly for adoption, has two disadvantages, one that nervous people always fancy there is a draught if they see anything like a window open, and the other a much more practical one, but one that is common to most forms of ventilation that are inexpensive—that a certain quantity of blacks enter. These conditions are, to a certain extent, got over by the plan suggested by several inventors—of boring holes through, or cutting pieces out of the lower bar of the upper sash. Such holes are not seen; and the air comes through them in a vertical direction into the room. They can also be fitted with little boxes containing cotton wool, through which the air will be filtered and deprived of soot, &c. This, of course, very considerably diminishes the amount of air that enters, and the cutting also weakens the framework of the window. I may here mention Currall's window ventilator, which consists of a metal plate fastened along the lower bar of the lower sash, and parallel to it, with an opening below the sash for the admission of air, which is thus deflected into a vertical direction by the metal bar. Here will be also a convenient place to mention the automatic sash fastener patented by Messrs. Tonks and Sons, by means of which the window is securely fastened when opened to the extent of three or four inches, either at the top or bottom, so that the window can be left open without anyone outside being able to open it further. This can also, obviously, be combined with the window block placed underneath the lower sash, so that air can be admitted in the proper direction, and the window still be securely fastened.

Louvred ventilators may also be used in a variety of ways in connection with windows. Where there are venetian blinds, it is only necessary to open the top sash, pull the venetian blinds down in front of the opening, and place the louvres so that they give the entering air an upward direction. Glass louvres fixed in a metal framework, may also be used, a pane of the window being taken out and one of these ventilators substituted for it. The louvres can be opened and shut by means of a string, and they are so fixed that it is impossible to break them by doing so. They are generally fixed instead of one of the top panes of the upper sash. It is better to place them lower down in the upper sash; and this is true of all inlets of air. If they are too high up, the air being admitted in an upward direction, impinges against the ceiling, rebounds into the room, and produces a draught. The metal frame-work of these ventilators requires oiling and attending to, or it will get rusty. In some places fixed louvres of wood, or still better, of strong glass, may be fixed with advantage, or swinging windows with sashes hung on centres may be used, as, for example, in water-closets; and these, where it is advisable, may be prevented from being closed by a means of a small wedge of wood screwed to the frame-work. The blind so often placed across the lower part of a window may also advantageously be used as a ventilator, or, where no blind is required, a glass one may be used, this being made to swing forward on its lower edge, so as to give the entering air an upward direction when the lower sash is opened, as in the model here shown, which was presented by Messrs. Howard to the Parkes Museum. Where very large quantities of air require to be admitted, one or more sashes of a window may be made to swing forward in this way, as is now done in the large hall of Willis's Rooms. Near to all windows, in the cold weather, the air of the room is colder than at other parts of the room. This may be obviated, when considered advisable, by the employment of double windows, the layer of air between the two windows preventing, to a very considerable extent, the cooling of the air inside the room. It is not advisable to have double panes of glass in the same sash, as the moisture between them will render them more or less opaque in certain states of the weather. With double windows, air may be ad-

mitted by opening the outer one at the bottom and the inner one at the top. Where French casement windows are used, as they sometimes are unadvisedly in this climate, ventilation may be provided by having a louvred opening above the casements of the window, or by making a glass pane or panes capable of being swung forward on the lower edge. Lastly, Cooper's ventilator is largely used for windows, and also in the glass panes over street doors. It consists of a circular disc of glass, with five holes in it, placed in front of a pane of glass with five similar holes, and working on an ivory pivot at its centre. It can be moved so that the holes in it are opposite to those in the window pane, when air will, of course, come in; or, so that they are opposite to the places between the holes in the panes, when the air will be prevented from entering. It is obvious that the air is not admitted in an upward direction, but the disadvantage of this is partly counterbalanced by the fact that it is admitted in five small streams, and not in one large one, so that there is less probability of a draught.

The air may also be admitted through apertures made in the walls or doors. The simplest way to do this is to make a hole through the wall, and fasten a piece of board in front of it in a sloping manner, so as to give the air an upward direction. It is better to put "cheeks," as they are called, on the sides, for they serve not only to attach the sloping board to the wall, but to prevent the air from falling out sideways into the room. This ventilator may be hidden by hanging a picture in front of it, and will cause no draught. I may state here that it is better, in a large room, to have two or more small ventilators of any kind whatever than one large one, and that no single inlet opening should be larger than a square foot. Openings of half that size are preferable. It is calculated that there should be 24 square inches of opening per head, so that a square foot would be sufficient for six persons. In such an opening as has been described, wooden or glass louvres may be placed. The same end may be attained by making one of the upper panels of a door to open forwards with hinges to a certain distance; or, even in some instances, by fixing it in this position. An obvious disadvantage, and one which always has to be considered in making openings through walls and doors, is that conversation which goes on in the room can be heard in the passage outside. Sherringham's valve is a modification of this plan, and can be fitted either into an outer wall or into one between the room and the passage or hall. It consists, as you see, of a metal box to fit into the hole in the wall, with a heavy metal flap, which can swing forwards, and is exactly balanced by a weight at the end of a string passing over a pulley, the weight acting as a handle, by means of which the ventilator can be opened or shut or kept at any desired position. What has been said before applies to these ventilators. They should not be placed too near the ceiling, and this is the mistake that is generally made in fixing them. Stevens's drawer ventilator may also be mentioned here. The name almost describes it. It resembles a drawer, which is pulled out of the wall for a certain distance, and allows air to come into the room vertically in several streams between metal plates placed inside the drawer. Jennings's "Inlet," which is in use in the barracks, consists of an opening through an outer wall, into a chamber in which dust, &c., is deposited, and thence between louvres into the room. Here I may mention that it is sometimes advised to place perforated zinc or wire gauze outside the entrance to the ventilators, so as to prevent dust, &c., coming into the room. This is not advisable, as the apertures get clogged up, and the entrance of air is much impeded. It is better to have an iron grating which will prevent birds entering, and to employ other methods for preventing the entrance of dust, soot, &c. Where this is considered necessary, the plan of passing air through cotton wool, which must be frequently changed, may be adopted. Currall's ventilator for admitting air through the door is sometimes useful. It resembles his window ventilator almost exactly; a long slit is cut through the door, a perforated metal plate placed outside, and a flat plate fixed parallel to the door inside and in front of the slit, thus giving the air as it comes into the room an upward direction. An admirable plan for the admission of air into rooms is by means of vertical tubes —an old system, but one which has been brought into prominence of late years by Mr. Tobin. A horizontal aperture is made in the wall into the outer air just above the floor, and then a vertical pipe carried against the wall to a height of from four to five feet. The cold air is thus made to ascend like a fountain into the room. It does so in a compact column, which only perceptibly spreads after it has got some height above the mouth of the tube. It then mixes with warm air at the top of the room, producing no draught at all. In spite of the vertical height through which air has to pass before it emerges into the room, a considerable amount of soot and dust of various kinds is brought into the room. This may be obviated by placing a little cotton wool in the interior of the tube. This, however, although a very efficient plan, has the serious disadvantage of impeding the current of air. A better plan is the one patented by the Sanitary Engineering and Ventilating Company; a tray containing water is placed in the horizontal aperture in the wall, the entering air being deflected on to the surface of the water by metal plates. The greater part of the dust is thus arrested by the water, which can be changed as often as necessary. In warm weather ice may be placed in the trays. Another plan is to place in a vertical tube a long muslin bag with the pointed end upwards, and kept in shape by wire rings. This provides a large filtering area, and offers very little resistance to the passage of air. The bag may be taken out and cleansed as often as necessary.

Several contrivances have been devised for the admission of air close to the floor, just behind a perforated skirting board. Among these are Ellison's conical ventilator, shown in the last lecture, and Stevens's skirting board ventilator, in which metal cups are placed in front of the inlet openings, and so distribute the air that no draught is felt. I think, however, that it is only advisable to admit warmed air at a low level into rooms, but there is no reason why such openings should not be made high up in the rooms—behind cornices, for example. Pritchett's paving, made

of agricultural pipes, may also be used for making walls and partitions, and is obviously applicable for ventilation purposes, whether used as inlet or outlet.

We now come to speak of exit shafts and valves. The first and most important of these is the chimney, about which I have already spoken. I need only add here that it is advisable to do without the use of cowls upon chimneys wherever it is possible. If the chimney can be made high enough it will not require a cowl, and if it cannot, a simple conical cap is generally sufficient to prevent down draughts. There is no doubt, however, that Boyle's fixed chimney cowl for preventing down draught not only does so, but produces an up draught in the chimney when the wind blows down upon it, as I can readily show you by an experiment with the model I have here. A small piece of wool is made to ascend in a glass tube by blowing vertically down upon the fixed cowl placed upon the top of it. Of revolving cowls for chimneys, the common lobster-backed cowl is probably the best. Whilst speaking of cowls, I may as well mention that a variety of cowls, some of which I have here, have been invented with the object of increasing the up draught in exit shafts of various kinds, some are fixed, as Boyle's, Buchan's, and Lloyd's, and some revolving, as Scott, Adie, and Co's., Howarth's, Stidders, Banner's, Stevens's, and the one invented by Mr. Boyle, but discarded by him some years ago. Whether any of these cowls increase the up current in exit shafts is a matter which is still under investigation, but I can show you, quite easily, that the common rough experiment, by means of which they are supposed to do so, is entirely fallacious. Cotton wool is drawn up a tube at least as easily by blowing across it in a slanting direction as by blowing through a cowl placed on the top of it. The fixed cowls have the advantage that they cannot get out of order. The revolving cowls have the disadvantage which is common to all apparatus with moving parts, that they are certain to get out of order some day or other. Whether they increase up draughts or not, there is no doubt that most of them prevent down draughts, and, like any other cover, prevent the entrance of rain.

Openings are sometimes made high up in the room into the chimney flue and protected by valves, the best known of which is Arnott's valve, which consists of a light metal flap, swinging inside a metal frame work in such a way that it can open towards the chimney flue, but not towards the room. Any pressure of air from the room towards the flue will, therefore, open it and allow the air to escape from the room into the flue. Pressure of air the other way will shut it. The disadvantages of this ventilator are that it makes an irregular noise, although this has been, to a considerable extent, obviated by the india-rubber padding with which it is now fitted. It also occasionally admits a little soot, and, of course, air at the same time, from the flue into the room. Boyle's chimney ventilator, made by Messrs. Comyn, Ching, and Co., is a modification of this. Instead of the light metal flaps, there are a number of small talc flaps. These make little or no noise, but they are liable to be opened by a current of air in the chimney. It is obviously, it seems to me, at variance with sound sanitary principles to make openings from the interior of the room into the chimney flues, and then to trust to valves for preventing the air of the flue from coming in. A far better plan is to have shafts placed by the side of the flues, and this, of course, is better done when the houses are built. The easiest and most satisfactory way of doing it is by means of air and smoke flues combined, in which the air flues are moulded in the same piece of fireclay as the smoke flue itself. These air flues can be connected with the upper parts of the rooms, and up draughts will be inevitably caused, as the air in them will be considerably heated on account of its immediate contact with the outer side of the flue. Such shafts can only serve as inlets when the flues are cold, and so it is advisable to use them especially with flues that are always hot—as, for instance, that of the kitchen chimney—and it is desirable, wherever it can be done, to connect the kitchen with a different air-shaft from the other rooms, or it is possible that air from the kitchen may get into some of the other rooms of the house.

Of exit ventilators not connected with the chimney flues, I may mention Mackinnell's, which also provides an inlet for air as well, and which is very useful in little rooms, closets, &c., having no rooms over them. It consists of two tubes, one inside the other, passing through the ceiling into the outer air. The inner one is larger than the outer one, and projects above it outside and below it an inch or so into the room. At its lower end a circular rim is attached horizontally parallel to the ceiling. The outer air enters between these two tubes, and is deflected by the rim just mentioned along the ceiling, so that it does not fall straight into the room. The vitiated hot air passes out by the inner tube, the action of which is, of course, considerably increased if a gas burner or other light be placed beneath it. It is upon this principle that the lamps for lighting railway carriages are made, the reflector answering the purpose of the rim round the end of the inner tube, and the air to supply the lamp coming in between the reflector and the glass shade, while the products of combustion escape through the pipe leading from the middle of the reflector, and immediately over the flame. Of course Mackinnell's ventilator requires a cover to keep out the rain, and it is necessary, in fact, to have a double cover, so that the heated air which escapes by the inner tube shall not be carried back into the room by the entering air. Tossel's ventilator is a variety of this, with a cover by means of which the action of the wind is able to be taken advantage of. The same inventor has also contrived one which can be used between the ceiling of one room and the floor of the room above, provided that this space can be well ventilated.

This brings us naturally to say a little about lighting. Candles, lamps, and gas, help to render the air impure. It is calculated that two sperm candles, or one good oil lamp, render the air about as impure as one man does, whereas one gas burner will consume as much oxygen and give out as much carbonic acid as five or six men, or even more. This is why it is commonly considered that gas is more injurious than lamps or candles, and so it is when the quantities of light are not compared, but with the same quantity of light, gas renders the air of a room less impure than either lamps or candles.

If, in the dining-room, instead of using five or six gas burners, as we too often do without any provision for the escape of the products of combustion, we used 40 or 50 sperm candles instead of 6 or 8, we should have a fairer comparison between gas and candles.

I have no time to enter into a discussion of the relative merits of various kinds of candles and lamps, but with regard to gas I would say that, considering the fact I have just stated, it is always advisable to provide a means of escape for the products of combustion immediately over the gas burners. By this, not only may these products be carried away, but, with a little contrivance, heated air may be drawn out of the room at the same time, and so an efficient exit shaft provided, in addition to the one found already in the chimney. Very simple contrivances will answer this purpose. A pipe, with a funnel-shaped end, starting from over the gas burner, and carried straight out into the open air, with a proper inlet opening, is all that is required in some instances, as in badly placed closets. For large rooms, the sunlight ventilators are found to answer admirably. They should be provided with a glass shade, placed below them to intercept the glare, and to cut off a large portion of the heat. An elegant contrivance for dwelling-rooms is Benham's ventilating globe light. In this, the products of combustion of the gas pass along a pipe placed between the ceiling and the floor of the room above, into one of the flues. This pipe, being surrounded by another opening into the ceiling of the room at one end, and into the flue at the other, is guarded at its entrance to the flue by a valve which can be easily shut when the gas is not burning. This double tube, as it passes under the floor of the room above, is covered with a fire-proof material, so that the floor is not affected by it. The joists, where they are notched, have iron bearers put across to support the floor boards above. Air is admitted by another pipe passing through the wall of the house into the external air, and ending also in the ceiling of the room by openings around those of the exit shaft. Thus warm air is introduced into the room at the same time that vitiated air from the upper part of the room, and also the products of combustion of the gas, are carried out of it into the chimney flue.

I may say a few words about some grates and stoves that have been devised with the view of combining ventilation and heating. The first of these is Captain Douglas Galton's grate, in which there is an air chamber placed around the flue, and communicating on one side with the external air, and on the other with the atmosphere of the room by various apertures. The outer air which passes into this chamber is warmed by contact with the heated flue, and issues into the room, thus supplying the room with warmed air, and utilising a considerable quantity of the heat that would otherwise be lost. There are several other grates, such as the Manchester school grate, made upon this principle, with variations in the arrangement of the inlet apertures, which are placed vertically like Tobin's tubes, &c. It is important in all these contrivances, where the outer air passes through a chamber in which the back of the grate and the flue is placed, that the back of the grate and the commencement of the flue in that chamber should be cast in one piece of metal, so as to have no joint. If there are joints they will become after a time defective, and air from the flue is liable to escape into the chamber round it and be brought back into the room by the entering air. Some slow combustion stoves, as George's "calorigen," have air pipes passing through them, and have the external air warmed on its way through the stove into the room. Iron slow combustion stoves dry the air too much, and unless they are lined with fire-clay, are apt to become too hot, and to cause an unpleasant smell in the room by the charring of the organic matter in the air. They are much more suitable for warming large buildings, where economy of fuel is an important object, than they are for use in sitting-rooms or offices. It is usual to place a vessel of water on the top of these with the view of obviating, as far as possible, the dryness of the air that they produce. It must be borne in mind that closed slow combustion stoves do not act as ventilators, as the air to supply the fuel—usually coke—is brought by a pipe from outside, and this is another reason why they are not so advantageous as an open fire or a quick combustion stove in dwelling-rooms. In the Thermhydric grate of Mr. Saxon Snell, a small boiler is placed behind the grate, and communicates with a series of iron pipes alongside of it. These are filled with water, which is, of course, kept warm, and air is admitted to the room between these hot water pipes. Thus, it is neither dried nor heated too much. The products of combustion are carried away by a flue, which may be placed under the floor; so that the grate, if required, may stand in the middle or in any other part of the room.

Gas stoves are gradually becoming largely used instead of coal, and, when proper provision is made for the escape of the products of combustion, they are certainly very convenient, and cleanly contrivances. I have no doubt that this will, in the end, be found to be the proper use for gas, and that we shall cease entirely, or almost entirely, to use coal in our houses. By using coal in the way that we do, we lose all the valuable bye-products—the ammonia, the tar, the carbolic acid, aniline dyes, &c., which are derived from the refuse of gas works, and which are worse than useless to us in our fires. Gas may be burned either mixed with air or not. In the first instance, a gas stove or grate filled with pumicestone or asbestos does not much resemble an ordinary fire, but if the gas be burned unmixed with air it is almost impossible to tell the difference. Generally speaking, it is found necessary, when there are several gas stoves in a house, to have a special supply of gas with larger pipes for them. What the gas companies should do is to lend gas stoves of various kinds, especially cooking stoves, to their customers for a small annual payment, as is done very successfully in continental cities. It is important that gas cooking stoves should not give an unpleasant smell of unburnt gas as some do. This is not only a waste but a nuisance, as coal gas always contains carbonic oxide (an extremely poisonous substance), and should, therefore, not be allowed to escape into the air, even in the smallest quantity

I have now to mention an artificial system of ventilation which has been lately introduced by Messrs. Verity Bros. It consists essentially of a fly-wheel fitted with fans or veins. The wheel is made to revolve by a jet of water directed against it, and supplied from a cistern overhead, the water passing off by a pipe into a cistern below. The apparatus can be fixed either in an inlet opening, and so made to propel air into the apartment through an aperture in the wall placed higher than people's heads, and made in a slanting direction, so that the entering air is shot upwards towards the centre of the room; or it can be used as an extractor, by placing it in an exit shaft, and causing it to draw the vitiated air out. The supply of water can be regulated by taps to the greatest nicety, so that the wheel can be made to revolve at whatever speed is desirable. The entrance pipes are sometimes fitted with a vertical tube containing a box, in which ice can be placed, or a holder for perfume, or any deodorant. For smoking rooms it is found advisable to use the apparatus as an extractor only, and to allow the air to come in by means of Tobin's tubes.

Dwelling-houses are seldom warmed and ventilated by means of hot-water apparatus, and so I do not think it necessary to enter into a description of the plans by which this may be effected. I need only mention Mr. Pritchett's "miniature hot water apparatus," if I may so call it, by means of which a single room may be warmed and ventilated. The water starts from a small boiler, the size of an ordinary kettle, which may be placed on a fire anywhere, or heated by a spirit lamp, and passes through a narrow space between double cylinders, the inner cylinders being used for the admission of fresh air, which is warmed in passing through them, or for the extraction of foul air. The water is made to pass through the extraction cylinders first, while it is hottest, and then through the others and back to the boiler. The cylinders are placed vertically, so that the air is admitted into the room in the proper direction. Other systems of artificial ventilation are suited for large public buildings, but are not adapted for use in dwelling-houses.

NATIONAL WATER SUPPLY.

SUGGESTIONS FOR DIVIDING ENGLAND AND WALES INTO WATERSHED DISTRICTS.

Essay by Professor Ansted, F.R.S.

Motto.—"Water, water, everywhere,*
And not a drop to drink."

A systematic division of our country into districts for water supply, presumes the existence of a map in which the lines of water-parting between the river basins are marked, and the included areas are calculated. A map of this kind, prepared by Mr. Petermann, was published many years ago, and was accompanied by references to the rainfall in different parts of the country as then determined. This map was on a small scale (25 miles to an inch), and referred only to the larger catchments. Very similar maps were afterwards prepared and published in the Appendix to the Report of the Duke of Richmond's Commission, and again in the Sixth Report on the Pollution of Rivers. One of these, marked with lines of water-parting and notices of rainfall, was coloured geologically. These and maps prepared for the Reports on the Fisheries, are among the published evidence that will be referred to.

* Two essays were sent in under this motto.

The most important map in reference to the subject is that published by the Ordnance Survey, entitled, "Rivers of England and their Catchment Basins." This map is drawn to a scale of 10 miles to an inch, the maps just referred to being 25 miles to an inch. In it the whole of England and Wales is parcelled out into 215 districts, which vary in area from three square miles to 4,613. Of the whole number more than 60 are drainages of small unnamed streams or tracks, having no drainage system. Of named streams a considerable number are small, unimportant, and have no urban population.

Of the remainder, about 70 consist of complete river basins. The rest are basins either of independent streams or tributaries, but include adjacent tracts between the mouths of adjoining basins. In this map the area of each district is calculated, and the rainfall as given by Mr. Symons' returns, is indicated at a large number of stations throughout the different catchments.

It may be observed, with regard to this map, that no attempt is made to group the districts, that the areas of some of the complete river basins and of some tributaries do not agree with other measurements made carefully by engineers for special purposes and published, and that the rainfall records are imperfect and require revision. Notwithstanding these drawbacks, the Ordnance Survey river map must, at present, be referred to as the basis of any practical system of grouping river basins for water supply.

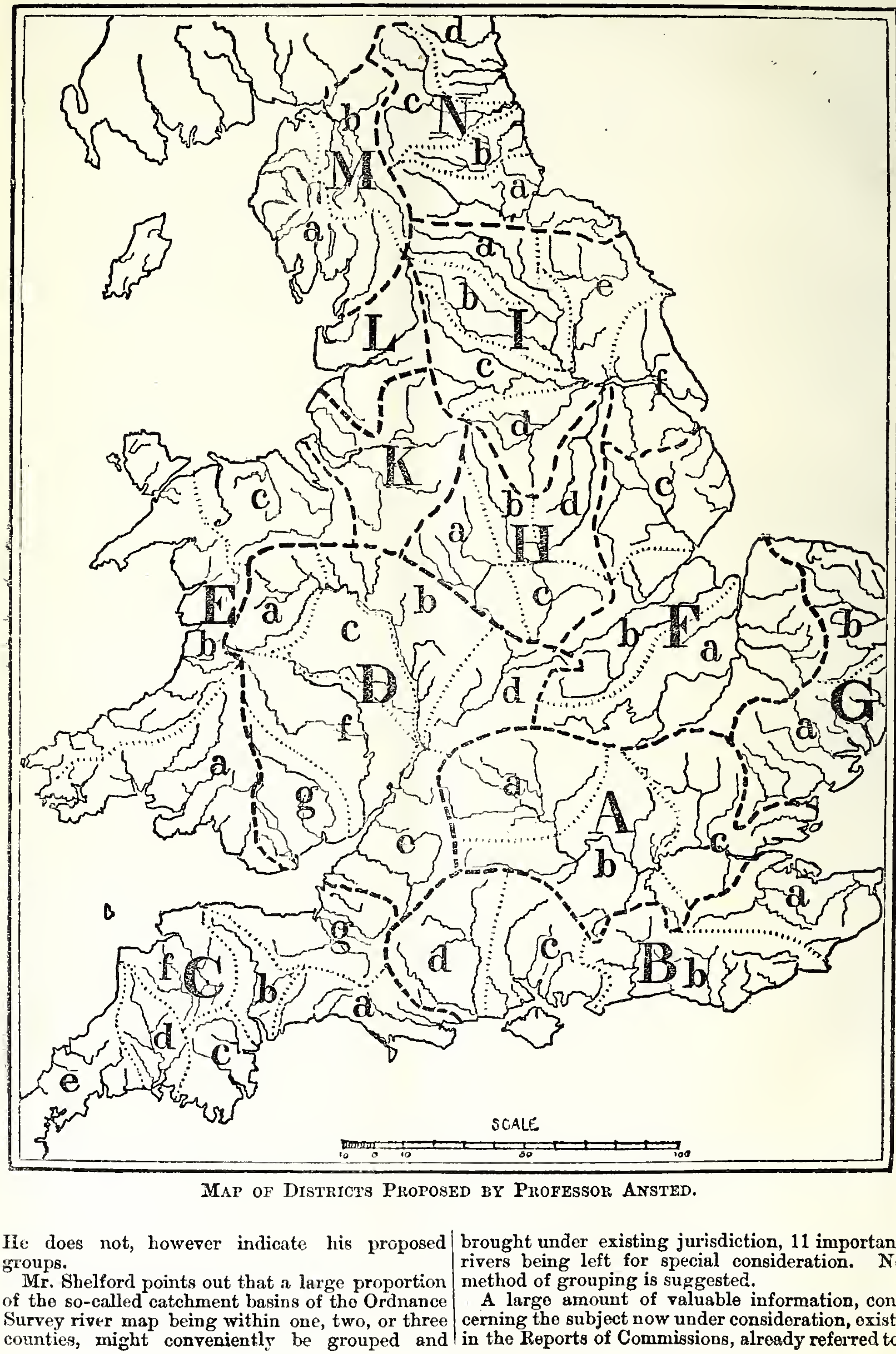
A work of my own, on "Water and Water Supply," recently published, contains a systematic account of the various catchments of the British Islands, arranged in 18 principal groups, eight of them English, and much information on the general subject of the distribution of surface waters. It contains, also, a number of estimates of the areas of catchments, and of portions of the larger river basins, and many references to the geology and topography of the basins.

In the published account of the Water Congress of last year, at the Society of Arts, there are suggestions by several authorities as to the grouping of the catchments for special purposes. The following are the most important:—

Mr. Conder suggests 10 groups, varying in area from 2,500 to 9,400 square miles, and in population from 1½ to 5 millions, but gives no details.

Mr. De Rance proposes 14 groups, varying greatly in extent, and not clearly defined. The area in each district occupied by rocks of the same geological age is stated, and also the area in each presumed to have permeable strata at the surface.

Mr. Parry advises a division of the country into 15 to 20 districts, as a proper number to admit of the supervision of each for water supply, by an engineer to be appointed for that purpose.



Map of Districts Proposed by Professor Ansted.

He does not, however indicate his proposed groups.

Mr. Shelford points out that a large proportion of the so-called catchment basins of the Ordnance Survey river map being within one, two, or three counties, might conveniently be grouped and brought under existing jurisdiction, 11 important rivers being left for special consideration. No method of grouping is suggested.

A large amount of valuable information, concerning the subject now under consideration, exists in the Reports of Commissions, already referred to,

and in other Parliamentary and official documents, but the author is not aware of other special suggestions concerning the grouping of catchments, than those just alluded to.

Under these conditions of published evidence, the following suggestions are offered:—

SURFACE WATERS.

1. To divide England and Wales into principal districts, each consisting either of one complete river basin, or of a group of adjacent river basins under similar physical conditions. Such a division is attempted in a tabular statement appended (see p. 772), and indicated in the accompanying map. Of the districts suggested, six are principal river basins, namely, the Thames, the Severn, the Ouse, the Trent, the Mersey, and the Ribble, the importance of the last two being due, not so much to the extent of their drainage area, as to the magnitude and number of the towns included within them. Five are groups of small adjacent catchments, within which are comparatively few large towns, and which have a small urban population. One group comprises three principal rivers, all entering the sea by a common estuary, the Wash; and one comprises the river basins of Durham and Northumberland, which have important natural relations, and form a convenient group. Of these 13 divisions, the statement referred to shows, in each case, (1) the total drainage area included, (2) the mean annual rainfall over the whole area, (3) the total urban population, estimated from the population of towns of 1,000 inhabitants or upwards, according to the last census; and (4) the proportion of urban population to each square mile of drainage area.

2. To subdivide these districts into convenient and natural groups of moderate extent. In the case of the great rivers, many tributaries may be regarded as independent catchments, while others group themselves without inconvenience. The large groups of small catchments may be conveniently broken up into smaller groups. The sub-division thus suggested is attempted in Appendix I. to this memoir. In the tables here submitted there are 43 districts, of each of which the following particulars are given:—(*a.*) The geographical position of the river, tributary, or group of streams. (*b.*) An account of the geology of that part of the principal drainage area included, indicating especially the rocks in which the streams originate, those over which they flow, and the general nature of the drainage area. (*c.*) The extent of the drainage area included, stated in square miles. The authority for the figures is the Ordnance Survey map of rivers, corrected and modified in many cases by other published statements. (*d.*) The mean annual rainfall over the district, obtained by averaging the records within the drainage area published in the Ordnance Survey map. (*e.*) Urban population of the district. The areas included in these sub-groups, with the single exception of the catchment basin of the Great Ouse, are less than 2,000 square miles in extent, and allare above 500 square miles.

3. To tabulate the names, relative position, and extent of drainage area of all the streams in England and Wales, whether primary or tributary, within whose catchment areas there is any urban population, and to estimate the amount of such population with regard to each stream. The tabular statements offered in Appendix II. have been prepared to supply the facts required to carry out this suggestion. The catchment areas are, however, only given approximately, except in those cases where accurate measurements have been published, or where the rivers are referred to in the Ordnance Survey river map. The names of the principal or primary tributaries of the large rivers are given in these tables, but the names of many of the secondary feeders of importance will be found in Appendix III. It has been thought expedient in these tables to state the extent of country not included within the catchments, but estimated in the totals of drainage area of each sub-district.

4. To tabulate the names, position with regard to natural drainage and natural river basin, and population of all the towns in England and Wales of more than 1,000 inhabitants. The tabular statements in Appendix III. have been prepared to meet this suggestion. The number of towns tabulated is nearly 1,000, and they are so arranged as to indicate the position of each with regard to the river basins of the country, and with regard to other towns on the same stream.

5. The divisions and sub-divisions here proposed being accepted, it would be desirable, for the purpose of water supply, to collect and tabulate as many trustworthy analyses of the waters of each stream as can be obtained. A very large number of such analyses will be found in the Sixth Report on the Pollution of Rivers, others have been published in the work quoted on "Water and Water Supply," and others would be obtained from distinguished chemists.

6. A complete alphabetical index of the streams and towns mentioned in the lists and tables here suggested would be desirable for reference, should the suggestions be adopted.

7. A map on the scale of the Ordnance Survey river map, in which the position of every town and every stream is marked, and in which the divisions and sub-divisions adopted are duly inserted, would be of great interest and value for reference.

UNDERGROUND WATERS.

A supply of pure water to many towns, and to villages and collected populations not numbering 1,000 souls, must frequently depend on the possibility of reaching underground sources, and the cost incurred in rendering these sources available. It is suggested, however, that no division of our country into districts, other than those marked by certain colours on geological maps, would be of practical use, and as such maps are well known, it is not thought necessary to append one to the present memoir.

It addition to the great geological map of the survey, on a scale of one inch to a foot, and the reduced maps by Professor Ramsay and others, maps of small portions of the country have been prepared by Mr. Lucas as hydrogeological maps, which are of use to those who are seeking water in certain rocks.

Should the general suggestions for a division of

the country into groups here recommended be adopted, so far as surface waters are concerned, it would be desirable to supplement the tables given by preparing a list of the smaller populations situated on or near permeable and water-yielding rocks, and mark their position on a map on which the presence of permeable or impermeable rocks is indicated by a tint. According to the estimate of Mr. De Rance, about 20,000 square miles of England consist of permeable rock, nearly 9,000 being chalk, and nearly 7,500 triassic sandstone. The suggestions required by the Council do not, however, seem to extend to this part of the subject of water supply.

APPENDIX I.

Statement of Sub-Groups of Catchments in England and Wales, indicating the Geographical Position, Geology, Rainfall, Drainage Areas, and Urban Population of Each Group.

GROUP A.—The Basin of the Thames.

Statement of the sub-divisions of the basin, showing the geographical limits, the geology, the mean annual rainfall, and the extent of drainage area of each.

Geographical Limit.	Geology of the District.	Drainage Area in Square Miles.	Mean Annual Rainfall in Inches.	Urban Population in Area.
Upper Basin.				
a. The river from its sources to the gorge of the Thames near Pangbourn, including the early tributaries as far as the Tame.	All the early feeders of the Thames, as far as Oxford, originate in the Lias or lower Oolites of the Cottswolds, and flow entirely over similar rocks. Some of them run for a considerable distance over the Lias between banks of Oolitic rock. Below Oxford the river is joined by the Ock and the Tame. Both rise in the lower cretaceous rocks, but chiefly flow over Oolites; the Tame, however, passes through a tract of lower and upper greensand aud gault before reaching the Thames	1,800	28·0	128,000
Middle Basin.				
b. The river from Pangbourn to Teddington, with the tributaries on both banks.	The tributaries on the north rise in and flow over the chalk, the Coln passiug for a short distance over Londou clay near its junction with the Thames. The others rise in cretaceous rocks, but flow chiefly over London clay, and eocene sands. Below Reading the Thames flows exclusively over London clay	1,850	26·2	315,000
Lower Basin.				
c. The river from Teddiugton to the sea, with the tributaries.	The tributaries from the north rise in aud drain for some distance the chalk, some of them only entering the London clay near the river. The lower part of the Lea, and the whole of the Roding, the Ingerburn, and the Crouch, are exclusively in the London clay. The southern tributaries rise in lower cretaceous, or Wealden rocks, traverse a considerable breadth of chalk, and then pass over London clay, of which they draw a large area. The Ravensbourne flows entirely over London clay, and the Darent chiefly over chalk ...	1,675	26·3	3,731,000
		5,425		5,174,000

N.B.—The number of stations at which the rainfall is recorded is 56, of which 12 are in *a*, 23 in *b*, 6 in *c*, and 15 in *d*. The mean annual rainfall of the district is 26·6 inches.

Appendix I.—(*Continued.*)

GROUP B.—River Basins South of the Thames.

Statement of the sub-groups of catchments; indicating the geographical limits, the extent of drainage area, the geology of the district, the mean annual rainfall, and the urban population in each sub-group.

Limits of Sub-Groups.	Geology of the District.	Area of Catchment in Square Miles.	Rainfall in Inches.	Urban Population.
a. Basins of the Medway and the Kentish Stour, and the coast from Sheppey Island to Dover.	The sources of the Medway and its feeders, and the early course, are in the Hastings sand or Weald clay. The main stream, after flowing through the Wealden rocks, crosses and drains the rocks of the cretaceous series, chiefly the lower greensand and chalk. The Beult, a principal feeder, is entirely confined to the Weald clay. The Stour is is almost entirely a chalk river, crossing a patch of London clay in the northern catchment area	1,254	26	284,000
b. Basins of the rivers entering the sea between Dover and the Selsea Bill, and the intervening coast.	The rivers of this group rise in the Wealden rocks and cross these rocks before entering the cretaceous series. The streams flow chiefly over chalk in the latter part of their course. The Rother is entirely in the Hastings sands, and the Ashbourne in the Weald clay. The Adur and the Avon, in their upper course, receive several tributaries from the Weald clay, the others from the Hastings sands	1,404	30	241,000
c. Basins of the rivers entering the sea between Selsea Bill and the mouth of the Avon.	These rivers all take their rise in, and flow at first over the chalk, but then enter and drain the eocene beds of South Hampshire in their course to the sea. None of the streams are important in an economic sense, their course over the chalk not yielding a large flow of water. The tertiaries of the South Hampshire basin include extensive beds of sand	1,206	30·1	250,000
d. Basins of the Avon (Hants and Wilts) and Stour (Dorset).	The Avon rises in the lower cretaceous beds close to the southern rim of the Thames basin. It soon enters the chalk and flows over that rock for a long distance in Wiltshire, draining its surface by feeders, of which the Wiley is the principal. It then enters and crosses the the Hampshire tertiary basin to the sea. The Stour rises in and drains a considerable breadth of Oolitic rocks	1,132	30·7	77,000
		4,996		852,000

N.B.—The number of stations at which the rainfall is recorded in the district is 61, of which there are 19 in *a*, 23 in *b*, 10 in *c*, and 9 in *d*. The mean rainfall of the whole district is 28·8 inches.

GROUP C.—River Basins of the South-West of England.

Statement of the sub-groups of catchments; indicating the geographical limits, the extent of drainage area, the geology, the mean annual rainfall, and urban population of each group.

Geographical Limits.	Geological Description of the District.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
a. Basins of the Frome (Dorset) and the Piddle, and of the small rivers between the mouth of the Frome and that of the Exe.	The Frome rises in the Oolites, and in the early part of its course is fed chiefly from the lower greensand. It then crosses the chalk for a considerable distance. The latter part of its course is over the Hampshire tertiaries. The Piddle has a parallel course over similar rocks. The small streams as far as Bridport are on the Oolites. The Brit and Char on the Lias. The others flow in valleys cut into the new red sandstone, draining the overlying lower greensand.	752	32·2	67,000
b. The basin of the Exe.	The Exe rises and flows for some distance over the altered old red sandstone or Devonian series of North Devon, one of its tributaries (the Barle) being entirely Devonian. It then crosses a small breadth of middle carboniferous rock, and enters the new red sandstone, which it flows over, and drains by several feeders, for the rest of its course.	584	37·3	77,000
c. The basins of the Teign and the Dart, and small streams entering the sea between the Exe and the Tamer.	All these rivers proceed from and drain the granite of Dartmoor. Leaving the granite, they all, with the exception of the Teign, flow over and drain the Devonian rocks of South Devon. The Teign crosses and drains the new red sandstone in the lower part of its course....	628	47·5	139,000

Appendix I.—Group C.—(*Continued.*)

Geographical Limits.	Geological Description of the District.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
d. The basins of the Tamer and the Tavey, and that of the St. German's river (Lynher).	The Tamer rises in and flows for a long distance through the Devonshire representatives of the millstone grit, known as the culm measures. It then enters and crosses the limestones and slates of the Devonian period to the sea. The Tavy rises on the Dartmoor granite, and flows over the Devonian slates and limestones to the sea. The Lynher, or St. German's river, rises in the granitic boss of Brown Willey and Rough Tor, and flows entirely over Devonian rocks.	570	50·2	83,000
e. The basins of the Cornish rivers.	These streams, the Fowey and Fal in the south, and the Alan or Camel in the north, being the only ones of importance, rise in the granitic bosses of Cornwall, and drain the slates, schists and other metamorphic Devonian rocks of that county. North of the Camel, the coast drainage is over the culm measures.	1,311	42·5	92,000
f. The basins of the Torridge and the Taw.	Both these rivers rise on the northern slopes of Dartmoor, and immediately enter the culm measures, which they cross and drain. Almost the whole of their course and drainage are on these rocks, but some of the feeders of the Tawe proceed from the Devonian schists of North Devon.	818	50·3	41,000
g. The basins of the Parret, the Brue, and the Axe.	The Parret and its early feeders from the south, rise in the hills of lower greensand and oolitic rock, or from the lias on the borders of Devonshire. The River Brue flows entirely over lias, and several feeders of the Parret drain the same rock. The western tributaries of the Parret, however, cross the new red sandstone, rising in the Devonian slates. The Axe rises in the mountain limestone of the Mendips. As they approach the Bristol Channel, all these rivers flow over a large flat alluvial tract.	1,116	34·0	74,000
		5,809		573,000

N.B.—The rainfall is estimated from the records over 59 stations, and the mean is 41·3 inches. The stations are:—8 in *a*, 6 in *b*, 9 in *c*, 5 in *d*, 13 in *e*, 7 in *f*, and 11 in *g*.

GROUP D.—Basin of the Severn.

Statement of the principal sub-groups of tributaries, indicating their geographical limits, the geology, the extent of drainage area, the mean annual rainfall, and the urban population of each.

Limits of Sub-Group.	Geographical Description of the District.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
a. The Upper Severn and the basin of the Vyrnwy.	The country consists entirely of hard slates, schists, and metamorphic rocks of cambrian or silurian age, chiefly upper silurian	1,320	63·7	22,000
b. The tributaries and country on the left or north and east bank of the Severn, between the basin of the Vyrnwy and that of the Upper Avon.	Almost all the tributaries flow through and drain for the greater part of their course the upper and lower sandstones of the triassic period, which are, however, interrupted by the presence of permian sandstones, and the coal measures rising through them. The Perry rises in the Denbighshire coal-field, and crosses the bunter, or lower new red. The Tern, though chiefly confined to the trias, touches the coal-fields of Shropshire and South Staffordshire. The Worf drains chiefly the permian grits. The Stour, originating in the Dudley coal-field, chiefly drains the upper new red sandstone. The Salwarp crosses the same rock, though draining part of the lias	820	26·2	194,000
c. The Teme and small tributaries on the right bank of the Severn to the water-shed of the Wye.	The small brooks, and other feeders of the Severn between the Vyrnwy and the mouth of the Tern, drain a broken district of silurian, Devonian, carboniferous, and permian rocks, containing a very small urban population, and yielding little water to the river, except in flood time. The Teme and its feeders drain a large district of metamorphic slates, grits, and schists, chiefly of the silurian period	882	25·4	56,000

APPENDIX I.—GROUP D.—(*Continued.*)

Limits of Sub-Group.	Geographical Description of the District.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
d. The sub-basin of the Upper Avon.	This important tributary rises in the lias of Warwickshire, but soon enters the upper new red sandstone, and crosses the permian grits at the southern extremity of the Warwickshire coal-field. Passing again into, and crossing the new red, it once more enters the lias, and continues in that rock for the most part till it joins the Severn. It chiefly drains the lias	1,050	26·7	104,000
e. The sub-basin of the Lower Avon, and the small sub-basins between the Upper and Lower Avon.	Between the basins of the Upper and Lower Avon, the Cottswold hills approach the banks of the Severn, and there is only a narrow belt of lias intervening drained by the Chelt and some smaller streams. A large part of the drainage area of the lower Avon is in the oolites, beyond the edge of the Thames basin, and the river then crosses the lias and new red sandstone to the Bristol coal-field, which it drains	1,230	37·5	348,000
f. The sub-basin of the Wye, and the small basins on the right bank of the Severn adjacent.	The Wye and its chief tributary, the Lug, originate in and drain the altered silurian rocks of Wales, and the characteristic and typical old red sandstone grits and conglomerates of Herefordshire and Monmouthshire. Below Ross the Wye drains the Forest of Dean coal-field, and crosses a small belt of carboniferous limestone to reach the Severn	1,709	32·0	58,000
g. The sub-basins of the Taff and Usk, and small basins adjacent.	The Usk drains only the old red sandstone grits and conglomerates for a long distance, and then, fringing the mountain limestone that encloses the South Welsh coal-field, it receives some of the drainage of that district by small tributaries. The Taff rises in and drains the eastern part of that large coal-field crossing the old red sandstone to reach the Severn.	1,007	46·0	148,000
		8,018		930,000

N.B.—The mean annual rainfall of the Severn basin, is 37·5 inches. The number of stations at which rainfall is recorded is 66, of which there are in a—7; *b*—7; *c*—4; *d*—15; *e*—10; *f*—10; *g*—13.

GROUP E.—RIVER BASINS OF THE WELSH COAST.

Statement of the sub-groups of catchments, indicating their geographical limits, geology, drainage-area, average rainfall, and the urban population of each.

Limits of Sub-Groups.	Geological Description of the Drainage Area.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
a. Rivers draining south.	The basins of the rivers of this sub-group may be further sub-divided into two; the eastern, in which the country drained, consists of the South Welsh coal-field; and the western, commencing with the Towy, comprising the altered rocks of the older palæozoic series. All the streams of the former rise in the grits and conglomerates of the old red sandstone, and cross a narrow belt of carboniferous limestone before entering and on emerging from the coal measures. Of the western rivers, the Cleddau crosses the Pembrokeshire extension of the coal-field...	1,936	43·8	136,000
b. Rivers draining west.	The whole of the western drainage of Wales is by torrents, which commence their course on the western slopes of the Welsh mountains, and flow entirely over the slates, schists, and altered rocks of that part of Great Britain. They cross no unaltered sedimentary rocks	1,044	56·6	37,000
c. Rivers draining north.	Of these the Conway and the Clwydd rise in the same metamorphic and igneous rocks as those of the former group, and cross silurian and cambrian slates and schists. The Dee rises in and crosses similar rocks for a long distance, but then crosses the Denbighshire coal-field to the lower new red sandstone, over which rock it continues to flow till its bed opens out into the wide estuary of the Dee	1,476	38·4	131,000
		4,456		304,000

N.B.—The mean annual rainfall as obtained from 34 stations in various parts of the drainage area of this group is 47·2 inches. The number of stations in the southern district 8, in the western district 14, and in the northern district 12.

APPENDIX I.—(*Continued.*)

GROUP F.—BASINS OF RIVERS DRAINING INTO THE WASH.

Statement of the river basins, and of the geology, mean rainfall, drainage area, and urban population of each.

Names of the River Basins.	Geology of the Catchment Area.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
a. The basin of the Great Ouse.	The early feeders of this river rise in and drain the lower oolites and the lias, but other tributaries soon join it, whose source is in lower cretaceous rocks or chalk. Crossing the lower oolites, the main stream flows for a long distance over the middle oolites, chiefly Oxford and Kimmeridge clay, with very little intervening limestone. From Huntingdon to the mouth of the river, the whole course is through low alluvial lands, the stream being fed by affluents from the Norfolk chalk.	3,021	24·0	171,000
b. The basins of the Nen and Welland.	The Nen rises on the oolites, but flows almost entirely over the lias, the river valley being cut through the oolitic rocks. Like the Great Ouse, the lower part of the river course is through the alluvial lands forming the fen district. The Welland rises near the Nen, and like it flows over and drains the lias till it enters the fen country. The rest of the course is over alluvial clays.	1,837	24·1	156,000
c. The basins of the Witham, and of the parts of Lincolnshire between the Witham water-shed and the eastern coast.	The Witham rises in and flows for a considerable distance over the lias, having a northerly course near the escarpment of the oolites. It then enters the fens, but receives feeders from the oolitic limestones and clays on each side. Its course from Lincoln to the outfall in the Wash is entirely over the flat lands of the fen district. The Steeping river, and other small streams, rise in the eastern side of the escarpment of the lower greensand, and drain that rock and the chalk, passing then through a belt of alluvium to the sea	1,508	24·9	69,000
		6,366		396,000

N.B.—The mean rainfall of the whole district, estimated from observations at 58 stations, is 24·2 inches. Of these stations, 34 are in sub-group *a*, 16 are in *b*, and 8 in *c*.

GROUP G.—THE RIVER BASINS OF THE EASTERN COUNTIES.

Statement of the groups of rivers, their geology, drainage area, rainfall, and urban population.

Geographical Limits of Sub-Groups.	Geology of the Districts.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
a. River basins of Essex and Suffolk.	The Chelmer, and the Pant or Blackwater, uniting in the estuary of the Blackwater, and the River Colne, take their origin in the chalk, but flow over and drain the beds of the London clay. The Stour and its principal feeders not only rise in but drain a large area of chalk before entering the London clay, but the whole of the lower part of their course is over that rock. The older tertiaries are much covered with gravel. The Suffolk rivers also flow over and drain a large area of chalk. In their lower course, the London clay is covered with the newer tertiary beds called "crag," and the rivers drain entirely this open shelly rock...	1,741	23·9	156,000
b. River basins of Norfolk.	These drain chalk almost exclusively, the patches of crag and London clay being small in extent and near the coast. The river valleys are generally in narrow breadths of tertiary rock, chiefly crag. Throughout the Eastern counties the rocks are much covered by gravel and superficial deposits, many of which hold back the water and admit of numerous land springs	1,481	25·5	176,000
		3,222		333,000

N.B.—The mean rainfall of the whole district is 24·7 inches, obtained from records at 33 stations. Of these 15 are in Essex and Suffolk, and 18 in Norfolk.

APPENDIX I.—(*Continued.*)

GROUP H.—THE BASIN OF THE TRENT.

Statement of the sub-divisions of the basin, and of the geographical limits, the geology, the drainage area, the rainfall, and the urban population in each group of sub-basins.

Geological Limits of Sub-Basins.	Geology of the District.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
a. The Upper Trent, and the sub-basin of the Tame.	The Trent rises in the North Staffordshire coal-field, which it drains by several feeders. It then crosses and drains the permian grits and sandstones, and enters the keuper, or upper member of the new red sandstone, which it crosses, and drains as far as the confluence of the Tame. The Tame rises in the South Staffordshire coal-field, and is fed by tributaries passing near or through the great manufacturing and industrial towns of that part of England By other tributaries it drains the Warwickshire and Leicestershire coal-fields. A large part of its course is over the upper new red sandstone, consisting of marls and sandstones.	1,260	28·8	865,000
b. The sub-basins of the Derwent and the Dove, and the intervening parts of the Trent.	The sources of the Dove, and its tributary the Churnet, are in the North Staffordshire coal-field and the millstone grit; and the Dove flows through a considerable distance of millstone grit and carboniferous limestone before reaching the new red sandstone, near Ashbourne. Beyond this its course is entirely in the upper new red or keuper sandstone. The Derwent is almost exclusively a millstone grit river, draining a part of the south-western extremity of the South Yorkshire coal-field. It then enters the new red sandstone of the valley of the Trent.	1,000	29·9	142,000
c. The sub-basin of the Soar.	Except the metamorphic rocks of Charnwood Forest, the Soar is a river flowing over and draining only the lias and new red sandstone. Its important feeders, including the Wreak, rise in and flow over the lias, but the main stream is confined to the keuper beds of the new red sandstone.	539	25·8	123,000
d. The Lower Trent, including the sub-basins of the Devon and the Idle.	After receiving the Soar, the Trent and its lower feeders flow through the new red sandstone, very near the escarpment of the lias. The Lean, from the north, drains the south-eastern part of the South Yorkshire coal-field and the permian rocks. The Devon and its tributary the Smite, are confined to the lias and the keuper sandstones. The tributaries of the Idle rise in the permian rocks, and flow over the lower new red sandstone, or hunter. The main stream of the Lower Trent flows altogether over the keuper.	1,280	25·8	147,000
		4,082		1,277,000

N.B.—The mean rainfall over the whole area, obtained from records at 39 stations is 27·35 inches. There are 9 stations in *a*, 10 in *b*, 8 in *c*, and 12 in *d*.

GROUP I.—THE BASINS OF THE OUSE AND HUMBER.

Statement of the various sub-groups of tributaries, and of the geology, the rainfall, and the urban population of each sub-group.

Groups of Tributaries.	Geology of District.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
a. The sub-basins of the Swale and the Ure.	The Swale rises in the millstone grit on the higher slopes of the Penine hills, and flows through narrow ravines in the mountain limestone to Richmond. Soon after it enters the new red sandstone. The Ure has a similar course to Masham. It then crosses the permian grits and limestones before reaching the new red sandstone near its confluence with the Swale.	950	36·3	21,000

Appendix I.—Group I.—(*Continued.*)

Groups of Tributaries.	Geology of District.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
b. The sub-basins of the Nidd and the Wharfe, and the course of the Ouse to the confluence of the Wharfe.	The greater part of the course of the Nidd is in the millstone grit, the bed of the stream reaching the mountain limestone. Near its junction with the Ouse it crosses the permian rock and the new red sandstone. The Wharfe crosses and drains a considerable tract of mountain limestone, then entering the millstone grit, and crossing the permian and triassic rocks like the other early tributaries of the Ouse. In all this district the rocks of the carboniferous system include many bands of shale, and are generally much fractured. The valleys are often occupied by boulder clay, which is in some places widely spread.	892	35·3	60,000
c. The sub-basin of the Aire and Calder.	This important district includes the northern part of the Yorkshire coal-field, and many large manufacturing towns. A large part of the Aire, however, and the upper part of the Calder, drain the middle carboniferous rocks of the millstone grit series. The Aire enters the coal measures near Bingley, and only drains a small part of the northern extremity of the coal-field. The Calder crosses similar rocks for some distance to the south. The two streams unite as the Aire leaves these rocks, and the united stream crosses the permian into the new red sandstone on reaching the valley of the Ouse...	815	35·5	676,000
d. The sub-basin of the Don.	The Don, like all the tributaries of the Ouse entering from the right, rises in the middle carboniferous rocks, but, unlike the others, enters the coal measures immediately, and the main stream, and all its early feeders, drain that part of the series almost exclusively. A little before reaching Doncaster it crosses the permian rocks, and there enters the new red sandstone. It enters the Ouse through a wide tract of low alluvial delta, in which its waters join those of the River Trent. ...	682	31·4	354,000
e. The sub-basin of the Derwent.	The Derwent, by numerous tributaries, originates in the oolitic hills of the north-east of Yorkshire, the river valleys being in the lias. Draining in this way a wide breadth of country, the feeders unite a little above Maldon, and thence proceed southward, crossing the lias into the new red sandstone. The stream then flows parallel to the Ouse in the new red sandstone valley and reaches the Ouse a little above the confluence of the Aire	814	27·3	19,000
f. The basin of the Humber.	The Humber, regarded as a separate basin, drains a breadth of low flat land extending from the escarpment of the lias to the sea. It flows over representatives of all the oolitic and cretaceous rocks, but a large part of the basin towards the sea is low-lying and alluvial. The drainage is effected by the Hull river on the north, and the Ancholme, or New River, on the south.... ...	1,253	23·6	194,000
		5,433		1,327,000

N.B.—The mean annual rainfall over the whole district, estimated from observations at 56 stations, is 31·2 inches. Of these, 6 are in *a*, 7 in *b*, 14 in *c*, 10 in *d*, 7 in *e*, and 12 in *f*.

Group K.—The Basin of the Mersey.

Geology of the Drainage Area.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
The early feeders of the Mersey originate in the middle carboniferous rocks or millstone grit of the Penine chain, and, after uniting, cross the southern part of the Lancashire coal-field into the new red sandstone, chiefly the bunter or lower member. The Irwell, the principal feeder from the north, here joins, having drained a large and important part of the coal-field, by several tributaries passing thickly-peopled towns and dstricts. The lower part of the Irwell drains part of the bunter sandstone. The Bollin and the Weaver, the important feeders of the Irwell from the south, drain parts of the North Staffordshire coal-field, but flow chiefly through and drain the keuper or upper member of the new red sandstone. The whole of the lower part of the course of the Mersey is over the bunter, except that the Sankey drains part of the south-western extremity of the Lancashire coal-field.	1,724	37 0	1,225,000

N.B.—The rainfall of the Mersey basin is estimated from records kept at 27 stations.

APPENDIX I.—(*Continued.*)

GROUP L.—THE BASINS OF THE RIBBLE AND THE WYRE.

Geology of the Drainage Area.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
The whole of the Upper Ribble, and all its feeders to the Hodder, as well as the Hodder itself, flow over rocks, chiefly limestone and slate, of the old carboniferous series. The Calder flows over and drains the coal measures, and the Darwen and Douglas, important tributaries, rise in coal measures and millstone grit, but cross and drain chiefly the new red sandstone, at first the bunter, but near the mouth of the river crossing the keuper. The Wyre rises in the millstone grit, and is largely fed from that rock, but the whole of the lower part of its course is over the upper new red sandstone, till approaching the sea, it reaches and traverses a wide tract of alluvium.	1,088	39·7	350,000

N B —The rainfall of the Ribble and Wyre is estimated from observations recorded at 9 stations.

GROUP M.—THE RIVER BASINS OF THE LAKE DISTRICT.

Statement of the groups of basins, their geographical position, geology, rainfall, and urban population.

Limit of Sub-Group.	Geology of the District.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
a. The basins of the Lune and Kent.	These rivers take their rise in the altered palæozic slates, schists, grits and limestones of Cumberland and Westmoreland, and flow over them for some distance. After crossing the silurian rocks, the Lune enters the mountain limestone, and reaches the sea, draining that rock. The Kent flows through a valley in the mountain limestone	673	44·8	46,000
b. The catchment of the rivers from the western water-shed of the Lake district.	These rivers all rise in the altered Cumbrian rocks of Cumberland and Westmoreland, which culminate in an irregular mountain group. As they approach the coast they cross a fringe of stratified rock, consisting in the south of keuper sandstone, and in the north of coal measures (the Whitehaven coal-field). The rivers flowing north cross first the coal measures, and afterwards the bunter, one or two of the smaller having their course almost entirely in these rocks not commencing in the Cumbrian	1,000	55·5	73,000
c. The basin of the Eden.	The Eden itself, and all its earlier feeders, rise in the middle and lower carboniferous rocks (millstone grit, and mountain limestone), and almost immediately enter the valley of the new red sandstone (keuper), through which the Eden flows throughout its course. One important tributary, the Eamont, rises in the lake mountains and expands into Ullswater lake before reaching the mountain limestone. As it approaches the sea, the river flows over the bunter, of which a small tract is laid bare, but the chief drainage is over keuper marls and sandstones	1,040	54·7	49,000
		2,713		168,000

N.B.—The mean rainfall over the district is 52·2 inches, obtained from observations made at 44 stations. Of these, 13 are in the sub-group *a*, 23 in *b*, and 8 in *c*. The mean rainfall in the lake district, excluding the valleys of the Lune and Kent is, however, 55·3 inches, over more than 2,000 square miles, far the heaviest in the British Islands.

Appendix I.—(*Continued.*)

GROUP N.—The River Basins of Durham and Northumberland.

Statement of the sub-groups of catchments, their geographical position, drainage area, geology, rainfall, and urban population.

Limits of Sub-Groups.	Geology of the District.	Drainage Area in Square Miles.	Rainfall in Inches.	Urban Population.
a. The basins of the Esk and the Tees.	The basin of the Esk, though entirely in Yorkshire, must be regarded as forming an extension of that of the Tees. It drains the northern part of a district of lower Oolites and Lias forming the Cleveland hills, and of late years well known for the ironstone worked in the neighbourhood. The Tees rises in the millstone grit of the Penine hills, and its upper feeders are in the shales and grits of the middle and lower carboniferous system. In its lower part it crosses the Durham coal-field and Permian rocks to the upper beds of the new red sandstone, and below the junction of the Skerne drains the latter rock	1,032	22·3	145,000
b. The basin of the Wear.	The Wear rises in and drains the millstone grit, and then turning to the north, enters and traverses the coal measures. It afterwards turns east, and drains part of the magnesian limestone and permian sandstones, till it reaches the new red sandstone, which it crosses to the sea	456	25·2	202,000
c. The basin of the Tyne.	The greater part of the drainage of the Tyne, as of the other rivers of this part of England, is in the millstone grit. The river afterwards enters the coal measures, crossing and draining the most important part of the Newcastle coal-field to the sea	1,130	31·7	364,000
d. The smaller basins of Northumberland.	These are several in number, but all rise in and drain similar rocks. The Blyth and the Wansbeck flow chiefly over coal measures. The Coquet is more a mountain limestone river, crossing however the northernmost extremity of the coal-field. Those further north are almost entirely mountain limestone rivers... ...	1,084	27·1	35,000
		3,702		746,000

N.B.—The mean rainfall, obtained from records at 34 stations, is 28 inches. Of these stations, 7 are in *a*, 6 in *b*, 11 in *c*, and 10 in *d*.

TABULAR STATEMENT OF THE PRINCIPAL GROUPS OF DRAINAGE AREAS IN ENGLAND AND WALES,

Shewing the total area included, the mean annual rainfall, and the urban population of each group.

References to the Groups.	Drainage Area in Square Miles.	Rainfall in Inches.	Total Urban Population.	Proportion of Urban Population to each Sq. Mile of Drainage Area.
A. The Basin of the Thames (excluding the Medway) ..	5,425	26·6	5,174,000	954
B. Basins of rivers south of the Thames Basin	4,996	28·8	852,000	170
C. Basins of rivers in the South-West of England	5,809	41·3	573,000	98
D. The Basin of the Severn	8,018	37·5	930,000	116
E. Basins of rivers draining the Welsh Coast	4,456	47·2	304,000	68
F. Basins of rivers entering the Wash	6,366	24·2	396,000	62
G. Basins of rivers of the Eastern Counties............	3,222	24·8	333,000	103
H. Basin of the Trent	4,082	27·35	1,277,000	313
I. Basins of the Ouse, Trent, and Humber	5,433	31·2	1,327,000	244
K. The Basin of the Mersey	1,724	37·0	1,225,000	710
L. Basins of the Ribble and Wyre....................	1,088	39·7	350,000	321
M. Basins of rivers of the Lake District	2,713	52·2	168,000	62
N. Basins of rivers of Durham and Northumberland....	3,702	28·0	746,000	201

APPENDIX II.

Names, Drainage-Areas, and Urban Population of the Basins of the various Rivers and Tributaries in England and Wales.

A.
Sub-Basins of the Thames Tributaries.

Tributary.	Area in sq. miles.	Population.
a. Upper Basin.		
l Churn	73	8,000
l Coln	87	2,000
r Cole	48	14,000
l Leach Brook	36	2,000
l Bampton Brook	120	4,000
l Windrush	141	4,000
l Evenlode	189	16 000
l Cherwell	400	9,000
r Ock	120	3 000
l Thame	300	21,000
Intervening areas	286	..
b. Middle Basin.		
r Pang	30	1,000
r Kennet	400	23,000
r Lodden	110	3,000
l Wick	50	7,000
l Colne	450	49,000
r Wey	380	28,000
r Mole	200	30,000
r Hog's Mill	30	14,000
l Brent	70	40,000
Intervening areas	130	..
c. Lower Basin.		
r Wandle	60	86,000
r Ravensbourne	80	91 000
l Lea	600	61,000
l Roding	317	13,000
l Ingerburn	63	6,000
r Darent	314	18,000
l Crouch	181	4,000
Intervening areas	60	..

N.B.—The urban population on the river banks is 5,617,000, distributed as follows:—*a*, 45,000; *b*, 120,000; *c*, 4,452,000.

B.
Rivers of Basins South of the Thames.

Basins.	Area.	Population.
A. Medway	680	135,000
Stour (Kentish)	373	32,000
Coast and intervening areas	201	117,000
B. Rother	312	16,000
Ashbourne	121	3,000
Cuckmere	75	2,000
Ouse	205	15,000
Adur	160	36,000
Arun	370	26,000
Coast and intervening areas	161	143,000
C. Titchfield	85	4,000
Hamble	35	3,000
Itchen	231	87,000
Test	477	19,000
Lymington	91	5,000
Coast and intervening areas	52	131,000
D. Avon	673	66,000
Stour (Dorsetshire)	459	11,000

C.
Rivers of Basins in the S.W. of England.

Basins.	Area.	Population.
A. Frome	187	8,000
Piddle or Trent	119	3,000
Wey	50	13,000
Brit	52	10,000
Lyme	39	2,000
Ax	165	5,000
Sid	21	4,000
Otter	82	8,000
Coast and small catchments	38	14,000
B. Exo	584	77,000
C. Teign	203	13,000
Dart	200	12,000
Aulne	54	2,000
Erme	43	4,000
Plym	59	71,000
Coast and small catchments	69	37,000
D. Tavy	85	8,000
Tamer	385	71,000
Lynher or St. German's	100	5,000
Looe	71	9,000
Fowey	120	2,000
Fal	50	14,000
Alan or Camel	149	9,000
Coast and small catchments	921	111,000
E. Torridge	336	14,000
Taw	455	20,000
Coast and small catchments	57	7,000
F. Parret	562	54,000
Brue	197	14,000
Axe	101	6,000
Coast and small catchments	256	..

D.
Tributaries of the Severn.

Tributaries.	Area.	Population.
A. Upper Severn	970	13,000
l Vyrnwy	350	9,000
B. *l* Perry	150	6,000
l Tern	250	21,000
l Worf	75	2 000
l Stour	150	111,000
l Salwarp	75	10,000
Intervening drainage	120	44,000
C. *r* Teme	660	9,000
r Small basins	222	47,000
D. *l* Upper Avon	1,050	104,000
E. *l* Small catchments	213	66,000
l Lower Avon	891	261,000
l Yeo	106	
F. *r* Leadon and small catchments:	100	6,000
r Wye	1,609	52,000
G. *r* Usk	540	44,000
r Taff	198	103,000
r Small catchments	269	

E.
Rivers of Welsh Coast Basins.

	Basins.	Area.	Population.
A.	Ogmore	114	4,000
	Afon	87	4,000
	Neath	118	9,000
	Tawe	106	52,000
	Llwchwr	156	17,000
	Gwendraeth Vawr	73	2,000
	Towy	514	17,000
	Taf	183	2,000
	East Cleddau } West Cleddau }	212	8,000
	Coast and small catchments	373	21,000
B.	Teifi	386	8,000
	Rheidol	75	7,000
	Dovey	217	3,000
	Mawddach	151	2,000
	Seiont	143	9,000
	Coast and small catchments	72	8,000
C.	Conway	222	6,000
	Clwydd	319	17,000
	Dee	818	92,000
	Coast and small catchments	117	16,000

F.
Rivers Draining into the Wash.

	Basins.	Area.	Population.
A.	Great Ouse. (Area.) Tove 140; Ouzel 200; Ivel 200; Kym 100; Cam 350; Lark 200; Little Ouse 350; Wissey 240; Nar 130; Small basins and river 1,111	3,021	171,000
B.	Nen	1,077	107,000
	Welland	760	49,000
C.	Witham	1,079	51,000
	Steeping River } Ludd } Small catchments }	101 139 189	18,000

G.
Rivers of Eastern Counties Basins.

	Basins.	Area.	Population.
A.	Chelmer } Pant } Blackwater	434	14,000 17,000
	Colne	192	32 000
	Stour	407	26,000
	Orwell or Gipping	171	48,000
	Deben	153	7 000
	Alde	109	7,000
	Blythe	79	5,000
	Small catchments	196	..
B.	Waveney } Wensum }	880	32,000 130,000
	Bure	348	6 000
	Small catchments	253	9,000

H.
Tributaries of the Trent.

	Tributary.	Area.	Population.
A.	r Lyme	20	16,000
	r Sow	234	26,000
	l Blythe	62	1,000
	r Tame	589	594,000
	Intervening area	355	..
	Population on river banks	..	86,000
B.	l Dove	393	32 000
	l Derwent	470	90,000
	Intervening area	137	..
	Population on river banks	..	20,000
C.	r Soar	539	123,000
	l Erewash	83	8,000
	l Lean	53	4,000
	r Devon	200	2,000
D.	l Greet	50	2,000
	l Idle	550	21,000
	Intervening area	347	..
	Population on river banks	..	110,000

I.
Tributaries of the Ouse and Humber.

	Tributaries.	Area.	Population.
	Ouse.		
A.	Swale	520	11,000
	Ure	430	13,000
B.	Nidd	320	14,000
	Wharfe	492	13,000
	Intervening areas	89	..
	Population on river banks	..	33,000
C.	Aire and Calder	815	676,000
D.	Don	682	354,000
E.	Derwent	794	17,000
	Intervening areas	47	..
	Population on river banks	..	2,000
	Humber Basin.		
F.	Ancholme	244	5 000
	Hull river	394	137,000
	Small catchments	595	..
	Population on river banks	..	27,000

K.
Tributaries of the Mersey.

Tributaries.	Area.	Population.
Goyt } Etherow }	130	28,000
Tame	60	81,000
Irwell	312	842,000
Bollin	112	50,000
Sankey Brook	107	62 000
Weaver	515	51,000
Small catchments	448	
Population on river banks		101,000

L.
TRIBUTARIES OF THE RIBBLE.

Tributaries.	Area.	Population.
Upper Ribble	355	60,000
Hodder } Calder }	234	
Darwen	57	102,000
Douglas	172	62 000
Population on river banks	..	120,000
Intermediate drainage ..	62	
Wyre	208	2,000
Population on coast		4,000

M.
RIVER OF THE LAKE DISTRICT.

Tributaries.	Area.	Population.
A. Lune	418	26,000
Kent	255	16,000
Intervening coast ..		4,000
B. Leven	202	11,000
Duddon	46	1,000
Esk	64	
Irt	61	
Calder	28	
Ehen	72	2 000
Derwent	262	16,000
Ellen	72	
Waver	70	
Wampool	28	3,000
Small catchments	95	40,000
C. Eden	915	47,000
Liddel	104	2,000
Intervening area	21	

N.
RIVERS OF DURHAM AND NORTHUMBERLAND.

Tributaries.	Area.	Population
A. Esk	147	21,000
Tees	708	111,000
Coast Drainage	177	13,000
B. Wear	456	202,000
C. Tyne	1,130	364,000
D. Blyth	131	3 000
Wansbeck	126	7,000
Coquet..	240	2,000
Aln	104	7,000
Till	231	2,000
Intervening coast	252	14,000

APPENDIX III.

NAMES AND POPULATIONS OF THE CITIES AND TOWNS WITHIN EACH RIVER BASIN OF ENGLAND AND WALES.

A.

NAMES OF TOWNS ON THE RIVER THAMES AND ITS CHIEF TRIBUTARIES, WITH THEIR POPULATION IN 1871.

(a.) Upper Basin.

Towns on the Thames.	Tributaries.	Town on tributaries.	Population.
	Churn	Cirencester......	7,681
Cricklade	......	......	1,845
	Coln	Fairford	1,626
	Cole	Swindon	11,720
	,, ...	Highworth	1,900
	Leach Brook	North Leach	901
	,, ...	Southrop	1,070
Lechlade ..	......	......	1,272
	Bampton Brook	Faringdon	3,252
	Windrush	Burford	1,403
	,, ...	Witney	2,976
	Evenlode	Moreton-in-the-Marsh	1,468
	,, ...	Stow-on-the-Wold ..	1,373
	,, ...	Charlbury	1 335
	,, (Glyme)......	Chipping Norton ..	3,641
	,, ,, ...	Woodstock	7,477
	Cherwell	Banbury	4,122
	,, ...	Deddington	1,540
	,, (Ray)	Bicester	3,018
Oxford	......	......	32 477
	Ock..........................	Wantage	3,295
Abingdon	......	...	5,799
	Thame	Wendover	5,790
	,, ...	Aylesbury	6,962
	,, (Branch)	Princes Risboro'	2,549
	,, ...	Thame	2,843
	,, ...	Watlington	1,943
Wallingford ...	......	......	2,972
	Pang	East Ilsley	1,032

(b.) Middle Basin.

Towns on the Thames.	Tributaries.	Towns on tributaries.	Population.
Reading	......	......	32,324
	Kennet	Marlborough...........	6,879
	,, ...	Hungerford	4,243
	,, ...	Newbury	7,703
	,, (Lambourne)	Lambourne	1,180
	,, (Embourn) ..	King's Clere	2,781
	Loddon	Wokingham	2,868
Henley	......	......	4,523
Great Marlow	......	.....	6,627
	Wick	High Wycombe	5,681
	,, ...	Beaconsfield	1,524
Maidenhead ...	......	.. ...	6,173
Windsor	......	......	11,769
Eton	.. ...	......	2,806
Slough	......	......	4,509
Datchet	... ..	......	990
Egham	......	......	5,895
	Colne	Berkhampstead	4,088
	,, (Gade)	Hemel Hempstead ...	5,996
	,, ...	King's Langley	1,495
	,, ...	Abbot's Langley	2,638
	,, ...	Watford	7,461
	,, (Ver)	St. Albans	8,298
	,, (Chess)	Chesham.........	2,244
	,, ...	Amersham	2,726
	,, ...	Rickmansworth	5,737
	,, ...	Uxbridge	7,497
	,, ...	Colnbrook	1,155
Staines	......	......	3,464

Middle Basin.—(Continued.)

Towns on the Thames.	Tributaries.	Towns on tributaries.	Population.
Chertsey	......	......	3,146
	Wey	Alton	4,092
	,,	Farnham	4,461
	,,	Godalming	2,444
	,,	Guildford	9,106
	,,	Woking	6,568
	,,	Weybridge	1,372
Shepperton	......	......	1,126
Walton	......	......	5,383
Sunbury	......	......	3,368
West Moulscy	......	......	563
	Mole	Blotchingley	1,9:6
	,,	Reigate	15,916
	,,	Dorking	5,419
	,,	Leatherhead	2,455
	,,	Cobham	2,133
	,,	East Moulsey	2,409
Hampton Wick	......	......	2,297
Esher	......	......	1,460
Thames Ditton	......	......	1,084
Surbiton	......	......	7,642
Kingston	......	......	15,263
	Hog's Mill	Epsom	6,276
	,,	Ewell	2,535
	,,	Maldon	5,586

(c.) *Lower Basin.*

Towns on the Thames.	Tributaries.	Towns on tributaries.	Population.
Ham	......	......	1,239
Twickenham	......	......	10,533
Richmond	......	......	15,113
Hounslow	......	......	9,294
Isleworth	......	......	11,498
Brentford	......	......	11,091
	Brent	Barnet	3,720
	,,	Finchley	7,146
	,,	Hendon	6,972
	,,	Edgeware	655
	,,	Harrow	4,997
	,,	Pinner	2,332
	,,	Hanwell	3,766
	,,	Ealing	9,959
Kew	......	......	1,033
Mortlake	......	......	5,119
Barnes	......	......	4,197
Chiswick	......	......	8,508
	(Branch)	Acton	8,306
Hammersmith	......	......	42,691
Putney	......	......	9,439
Fulham	......	......	23,350
Wandsworth	......	......	19,783
	Wandle	Carshalton	3,668
	,,	Croydon	55,652
	,,	Mitcham	6,498
	,,	Tooting	2,327
	,,	Streatham	12,148
	,,	Wimbledon	9,087
Battersea	......	......	67,218
London (North Bank)	......	......	3,188,219
London (South Bank)	......	......	713,057
Deptford	......	......	60,188
Greenwich	......	......	169,361
	Ravensbourn	Bromley	10,674
	,,	Lee	10,193
	,,	Eltham	4,539
	,,	Lewisham	36,525
	Lea	Dunstable	4,558
	,,	Luton	17,317
	,,	Hatfield	3,998
	,, (Beane)	Stevenage	2,909
	,, (Rib)	Buntingford	1,014
	,,	Hertford	7,169
	,,	Ware	4,917
	,, (Stort)	Bishop's Stortford	6,250
	,,	Hoddesdon	2,090
	,,	Broxbourne	2,872
	,,	Waltham Abbey	5,197
	,,	Epping	2,275

Lower Basin.—(Continued.)

Towns on the Thames.	Tributaries.	Towns on [tributaries.]	Population.
Woolwich	......	......	35,557
	Roding	Ongar	2,103
	,,	Wanstead	5,119
	,,	Barking	5,776
	Ingerburn	Romford	6,335
Erith	......	......	8,289
	Darent	Westerham	2,283
	,,	Sevenoaks	4,118
	,,	Wrotham	3,201
	,,	Farningham	854
	,,	Shoreham	3,678
	,,	Dartford	8,298
Purfleet	......	......	1,486
Greenhitho	......	......	1,452
Thurrock (Grays and West)	......	......	2,806
Tilbury	......	......	974
Gravesend	......	......	21,265
	Crouch	Billericay	1,451
	,,	Rayleigh	1,404
	,,	Rochford	1,589

B.

NAMES OF TOWNS ON THE RIVER BASINS AND THE COAST SOUTH OF THE THAMES BASIN, WITH THEIR POPULATIONS IN 1871.

Medway.

Tunbridge Wells	19,410
Eden—Bletchingly	1,916
Godstone	2,254
Edenbridge	1,891
East Grinstead	5,390
Tunbridge	15,378
Beult—Cranbrook	4,331
Maidstone	26,237
Rochester, Stroud, and Chatham	43,116
Sheerness	13,956
The Swale—Sittingbourne	6,418
Milton	3,463
Faversham	7,319
Whitstable	4,881

Herne Bay	5,703
Margate	11,995
Broadstairs	1,926
Ramsgate	14,640

Stour.

Ashford	8,458
Canterbury	20,962
Sandwich	3,060

Deal	8,009
Walmer	3,816
Dover	28,506
Folkstone	14,791
Sandgate	1,840
Hythe	3,383
Romney	1,129
Lydd	1,936

Rother.

Tenterden	3,669
Rye and Winchelsea	8,290
Battle	3,495

Hastings and St. Leonards	32,028
Ashburn.	
Hailsham	2,429
Cuckmere.	
Heathfield	2,044
Ouse.	
Uckfield	2,041
Lewes	10,753
Newhaven	2,549
Rottingdean	1,544
Brighton and Hove	90,011
Adur.	
West Grinstead	1,344
Cuckfield	4,420
Steyning	1,665
Shoreham	28,906
Worthing	7,413
Arun.	
Horsham	7,831
Western Rother—Petersfield	1,587
„ Midhurst	6,753
„ Petworth	3,304
Arundel	2,956
Littlehampton	3,272
Bognor	2,811
Chichester	9,054
Havant	2,634
Portsmouth and Southsea	102,000
Gosport	7,366
Fareham	7,023
Tichfield River.	
Tichfield	4,369
Hamble River.	
Bishop's Waltham	2,618
Itchen River.	
Alresford	2,204
Winchester	16,366
Twyford	1,442
Bishopstoke	1,579
Millbrook and Shirley	11,845
Southampton	53,741
Test or Anthon.	
Basingstoke	5,574
Whitchurch	1,965
Andover	5,501
Romsey	5,681
Lymington River.	
Lymington	5,356
Avon.	
Devizes	6,839
Amesbury	1,169
Wiley—Warminster	5,786
„ Heytesbury	993
„ Wilton	8,865
Salisbury	13,839
Ludgershall	554
Downton	3,654
Cranbourne	2,562
Fordingbridge	3,053
Ringwood	3,781
Christchurch	15,415
Stour.	
Stalbridge	2,096
Stourminster Newton	1,965
Blandford Forum	1,536
Wimborne Minster	5,019

C.

Names of Towns on the Coast and within the River Basins of the South-West of England, with their Populations in 1871.

Poole	10,097
Frome.	
Cerne Abbas	1,164
Bere Regis	1,676
Wareham	3,050
Dorchester	6,915
Corfe Castle	1,806
Wey.	
Weymouth and Melcombe Regis	13,259
Brit.	
Beaminster	2,585
Bridport	7,670
Lyme.	
Lyme Regis	2,333
Ax.	
Axminster	2,861
Colyton	2,479
Axmouth	702
Sid.	
Sidmouth	3,360
Otter.	
Honiton	3,464
Ottery St. Mary	4,110
Exe.	
Bampton	1,928
Tiverton	10,024
Silverton	1,288
Collumpton	2,967
Bradninch or Braines	1,914
Crediton	5,778
Exeter	44,226
Topsham	3,121
Exmouth	5,614
Dawlish	4,241
Teign.	
Moreton Hampstead	1,551
Chudleigh	2,042
Newton Abbott	2,194
Teignmouth	6,751
Torquay	21,657
Paignton	3,590
Brixham	6,542
Dart.	
Ashburton	2,952
Totness	4,073
Dartmouth	5,338
Kingsbridge	1,557
Aulne.	
South Brent	1,449
Erme.	
Ermington	2,010
Modbury	1,751
Plym.	
Plymouth	70,091
Plympton	1,084

Tavy.	
Tavistock	7,781
Tamer.	
Holsworthy	1,645
Launceston	2,935
Saltash	2,293
Devonport	64,074
St. German's River.	
Callington	2,173
St. German's	2,678
Looe.	
Liskeard	6,499
East and West Looe	2,194
Fowey.	
Lostwithiel	922
Fowey	1,394
St. Austell	3,803
Mevagissy	2,073
Fal.	
Tregony	745
Truro	3,059
Penryn	3,679
Falmouth	5,294
St. Mawes	1,003
Helston	3,797
Marazion	1,267
Penzance	10,414
St. Ives	6,965
Phillack	4,165
Camborne	7,757
Redruth	10,685
St. Michael's	1,000
St. Columb Major	1,113
New Quay	1,121
Camel.	
Camelford	1,250
Bodmin	4,672
Wadebridge	1,594
Padstow	1,991
Stratton	1,839
Hartland	1,871
Torridge.	
Hatherleigh	1,684
Okement—Oakhampton	1,900
Torrington	3,529
Bideford	6,969
Taw.	
Chumleigh	1,594
L. Dart—South Molton	3,978
Mole—North Molton	1,703
Barnstaple	11,659
Ilfracombe	4,721
Porlock	777
Minehead	1,665
Dunster	1,156
Crewkerne	3,557
South Petherton	2,065
Parret.	
Isle—Chard	2,400
,, Ilminster	2,431
Yeo—Yeovil	8,527
,, Ilchester	743
,, (*Branch*) Somerton	2,302
Langport	1,018
Tone.	
Wiveliscombe	2,059
Milverton	2,018
Wellington	5,199
Taunton	14,597
North Petherton	3,985
Bridgwater	3,539
Brue.	
Bruton	1,691
Castle Carey	2,021
Glastonbury	3,688
Shepton Mallet	4,163
Street	2,157
Ax.	
Wells	4,518
Axbridge	830

D.

Names of Towns within the Basin of the Severn and its Tributaries, with their Populations in 1871.

Upper Severn.	
Llanidloes	3,428
Newtown	4,874
Welshpool	4,033
Vyrnwy.	
Llanfilly	1,132
Llansaintfraid	1,362
Oswestry	7,036
Perry.	
Ellesmere	6,309
Shrewsbury	23,406
Tern.	
Whitchurch	3,696
Market Drayton	4,039
Mess—Newport	3,202
Roden—Wem	3,880
Wellington	5,926
Wenlock	19,401
Coalbrookdale	1,574
Ironbridge	3,605
Madeley	9,475
Broseley	4,639
Worf.	
Shifnal	2,190
Bridgnorth	5,320
Bewdley	3,021
Stour.	
Wolverhampton (part)	35,000
Dudley	43,782
Hale's Owen	2,984
Stourbridge	9,376
Kidderminster	19,473
Stourport	3,081
Salwarp.	
Bromsgrove	6,967
Droitwich	3,504
Worcester	33,326
Teme.	
Knighton	1,743
Clun—Clun	1,127
Ludlow	5,087
Tenbury	1,210
(*Branch*) Great Malvern	5,693
Upton-on-Severn	2,664
Tewkesbury	5,409

Upper Avon.

Rugby	8,385
Sow—Coventry	37,670
„ Southam	1,785
Leam—Leamington	20,910
Warwick	10,986
Kington	2,126
Stratford	7,183
Stour—Chipping Camden	2,013
„ Shipston-on-Stour	1,800
Arrow—Henley in Arden	1,101
„ Alcester	2,363
Evesham	4,880
Pershore	2,826

Chelt.

Cheltenham	41,923

Gloucester	18,341

Stroud Water.

Minchinhampton	4,361
Stroud	7,082
Painswick	4,019

Westbury-on-Severn	2,495
Newnham	1,483

Small Branch.

Dursley	2,413

Small Branch.

Wickwar	902
Wotton-under-edge	2,314
Berkeley	1,161

Small Branch.

Thornbury	1,630

Wye.

Builth	1,059
Talgarth	1,408
Hay	2,011
Hereford	18,327
Lugg—Presteign	2,460
„ Radnor	1,870
„ Aymestry	775
„ Leominster	4,749
„ (*Branch*) Kington	2,126
„ „ Pembridge	1,535
„ „ Weobley	932
Frome—Bromyard	1,322
Ross	3,586
Monnow—Monmouth	5,879
Chepstow	3,347

Lower Avon.

Tetbury	3,449
Malmesbury	3,123
Wootton Bassett	2,392
Calne	3,333
Chippenham	3,936
Corsham	3,390
Melksham	2,464
Trowbridge	11,508
Bradford	4,877
Marshfield	1,788
Bath	32,557
Keynsham	2,240
Bristol	182,523
(*Branch*) Chipping Sodbury	1,157
Portishead	2,137

Usk.

Brecknock	5,845
Crickhowel	1,464
Abergavenny	4,803
Usk	1,616
Pontypool	4,834
Caerleon	1,306
Newport	9,844
Tredegar	12,389
Caerphilly	2,309

Taff.

Merthyr Tydvil	51,949
Llandaff	11,922
Cardiff	39,536

E.

Names of Towns in the River Basins of Wales, and their Populations in 1871.

a. *Draining South.*

Ogmore—Bridgend	3,539
Afon—Aberafon	3,574
Neath—Neath	9,319
Tawe—Swansea	51,702
Llwchwr—Llanelly	15,281
„ —Lougher	1,280
Gwendraeth Vawr—Kidwelly	2,072
Towy—Llandovery	1,861
„ Llandeilo	1,470
„ Llangadoch	2,830
„ Carmarthen	10,488
Taf—Laugharne	1,742
East Cleddau—Narberth	1,266
West Cleddau—Haverford West	6,622

b. *Draining West.*

Teifi—Tregaron	1,788
„ Lampeter	1,225
„ Newcastle Emlyn	1,757
„ Cardigan	3,461
Ystwith } *Rheidol* } —Aberystwith	6,898
Dovey—Dinas Mawddy	797
„ Machynleth	2,042
Maddach—Dolgelly	2,357
Sciont—Carnarvon	9,449

c. *Draining North.*

Conway—Llanrwst	3,767
„ Conway	2,620
Clwydd—Ruthin	3,298
„ Denbigh	6,323
„ St. Asaph	1,900
„ Rhyddlan	1,233
„ Rhyl	4,229
Dee—Bala	1,539
„ Corwen	2,646
„ Llangollen	2,798
„ Ruabon	15,150
„ Chirk	1,919
„ Malpas	962
„ Wrexham	8,576
„ Holt	1,056
„ Mold	3,978
„ Hawarden	6,782
„ Chester	35,257
„ Flint	4,269
„ Neston and Parkgate	2,838
„ Holywell	3,540

Urban Population on the Coast.

a	Tenby	3,810
a	Pembroke	13,704
a	Wilford	3,252
b	St. David's	1,000
b	Fishguard	1,581
b	Cricueth	812
b	Pwlhelli	3,009
b	Nevin	1,791
c	Bangor	9,850
c	Llandudno	2,762
c	Abergele	3,194

F.

Names of Towns in the River Basins of Rivers Flowing into the Wash, and those of the Adjoining Lincolnshire Coast.

Great Ouse.

Brackley	2,351
Buckingham	3,703
Winslow	1,826
Stony Stratford	1,976
Wolverton	2,804
Tove—Towcester	2,465
Newport Pagnell	3,655
Ouzel—Tring	4,045
,, Ivinghoe	1,722
,, Woburn	1,605
,, Leighton Buzzard	4,696
,, Fenny Stratford	1,590
Olney	2,547
Harrold	1,042
Bedford	16,850
Ivel—Ampthill	2,220
,, Shelford	1,111
,, (*Hiz*) Hitchin	7,630
,, Baldock	2,036
,, Biggleswade	4,244
,, Potton	2,072
St. Neots	3,200
Kym—Kimbolton	1,509
Huntingdon	4,243
Godmanchester	2,363
St. Ives	3,291
Swavesey	1,335
Cam—Royston	1,801
,, Saffron Walden	5,718
,, Linton	1,838
,, Cambridge	30,078
Ely	6,114
Lark—Mildenhall	3,862
Little Ouse—Thetford	4,166
,, Brandon	2,216
Wissey—Walton	1,388
,, Swaffham	3,700
,, Stoke Ferry	706
Downham Market	2,752
Nar—Litcham	854
King's Lynn	17,266

Nen.

Daventry	4,051
Northampton	41,168
Wellingborough	9,385
Rothwell	2,448
Kettering	7,184
Higham Ferrars	1,232
Thrapston	1,223
Oundle	2,829
Kingscliffe	1,259
Peterborough	11,264
Saxby	1,393
Whittlesea	4,297
March	5,854
Wisbeach	9,362
Sutton St. Mary	4,253

Welland.

Market Harborough	2,362
Uppingham	2,464
Stamford	7,846
Guash—Oakham	2,911
Market Deeping	4,553
Crowland	2,459
Spalding	9,111
Glen—Grantham	5,028
,, Bourn	3,098
,, Donington	1,753
Glen—Swineshead	1,919
,, Holbeach	5,332

Witham.

Lincoln	26,766
Bain—Horncastle	4,865
Sleaford R.—Sleaford	3,592
Bolingbroke	947
Boston	14,526

Steeping River.

Spilsby	1,623
Wainfleet	1,355

Lincolnshire Coast.

Burgh	1,236
Alford	2,881
Ludd—Louth	10,500

G.

Names of Towns in the River Basins of the Eastern Counties, with their Populations in 1871.

Chelmer.

Thaxted	2,188
Dunmow	2,983
Chelmsford	9,318

Blackwater.

Braintree	4,790
Coggeshall	2,916
Witham	3,347
Maldon	5,586

Colne.

Halstead	5,783
Colchester	26,343

Stour.

Haverhill	3,031
Clare	1,887
Lavenham	1,886
Sudbury	6,908
Neyland	980
Bildeston	808
Bret—Hadleigh	3,575
Manningtree	970
Harwich	6,079

Gipping or Orwell.

Stow Market	4,097
Needham Market	1,393
Ipswich	42,947

Deben.

Debenham	1,349
Wickham Market	1,541
Woodbridge	4,403

Alde.

Framlingham	2,569
Saxmundham	1,292
Aldeburgh	1,990
Orford	1,022

Blythe.

Halesworth	2,437
Southwold	2,155

Waveney.

Diss	3,851
Eye	2,396
Harleston	1,662
Bungay	3,503
Beccles	4,844
Lowestoft	15,246

Wensum (Yare).

Fakenham	1,831
East Dereham	3,689
Norwich	80,386
Wymondham	2,150
Yarmouth	41,819

Bure.

Aylsham	2,346
North Walsham	2,842
Worstead	746

TOWNS ON THE NORFOLK COAST.

Cromer	1,423
Holt	1,563
Wells	3,044
Walsingham	1,509
Burnham Westgate	1,585

H.

NAMES OF TOWNS WITHIN THE BASIN OF THE TRENT, WITH THEIR POPULATION IN 1871.

Burslem	25,562
Hanley	18,407
Stoke-on-Trent	15,300

Lyme.

Newcastle-under-Lyme	15,948
Longton and Lane-end	19,748
Stone	3,732

Sow.

Eccleshall	1,484
Stafford	12,212
Penk—Brewood	3,237
„ Cannock	6,350
„ Penkridge	2,435
Rugeley	3,375

Blythe.

Abbotts Bromley	1,456

Tame.

Wolverhampton (part)	34,000
Wednesfield	9,000
Walsall	40,301
Wednesbury	116,809
Birmingham	343,787
Blythe—Coleshill	5,396
Anker—Nuneaton	7,399
„ Hinkley	6,902
„ Atherton	3,677
„ *Sence*—Market Bosworth	949
Tamworth	11,493
Lichfield	7,347
Mease—Ashby-de-la-Zouch	7,302
Burton-on-Trent	20,378

Dove.

Hartington	2,966
Ashbourne	5,310
Rocester	1,341
Churnet—Leek	11,331
Tean—Cheadle	2,929
Uttoxeter	3,604
Tutbury	2,149
Castle Donnington	2,154

Derwent.

Castleton	1,030
Hatherseage	1,021
Eyam	2,130
Wye—Buxton	3,717
„ Tideswell	1,915
„ Ashford	713
„ Bakewell	2,283
Darley	1,557
Winster	814
Matlock	5,220
Crompton	1,074
Bonsall	1,246
Wirksworth	3,338
Amber—Alfreton	3,680
Heage	2,195
Belper	8,527
Derby	49,810

Soar.

Leicester	95,220
Wreak—Melton Mowbray	5,011
„ Syston	1,877
Mount Sorrel	1,995
Barrow	5,857
Loughborough	11,588
Kegworth	1,834

Erewash.

Codner	3,689
Heanor	4,888

Lean.

Hucknall Torkard	4,257
Nottingham	83,621

Devon.

Bingham	1,629

Greet.

Southwell	2,400
Newark	12,195

Small branch.

Tuxford	1,016
Gainsborough	7,564

Id'e.

Mansfield	11,824
Maund—Ollerton	831
„ East Retford	3,194
Ryton—Worksop	1,486
„ Blythe	2,294
„ Bawtry	930
Epworth	2,295

I.

NAMES OF TOWNS ON THE BASINS OF THE OUSE AND HUMBER, WITH THEIR URBAN POPULATIONS IN 1871.

OUSE.

Swa'e.

Muker	913
Reeth	1,077
Richmond	2,520
Northallerton	2,663
(*Branch*) Bedale	1,026
Thirsk	3,040

Ure.

Hawes	1,843
Askrigg	607
Leyburn	887
Middleham	909
Masham	1,062
Ripon	6,806
Boroughbridge	857

Kyle.

Easingwold	2,153

Nidd.

Pateley-bridge	800
Ripley	1,334
Knaresborough	5,205
Harrogate	6,843
York	50,765

Wharfe.

Ilkley	2.511
Otley	5,855
Wetherby	1,657
Tadcaster	2,443

Cawood	1,179
Selby	6,193

Aire.

Gargrave	1,291
Skipton	6,042
Keighley	19,775
Bingley	15,952
Bradford Beck—Bradford	64,440
Bramley	9,882
Horsforth	5,465
Headingley	13,942
Leeds	259,212
Calder—Holme	724
,, Hebden-bridge	3,894
,, Sowerby-bridge	7,041
,, Sowerby and Luddenden Foot	9,211
,, Halifax	65.510
,, Elland	6,432
,, Brighouse	6.370
,, Rastrick	5,846
,, *Holme*—Holmfirth	5,613
,, ,, Honley	4,906
,, ,, Meltham	4,229
,, ,, Huddersfield	70,253
,, Dewsbury	24,764
,, Heaton	1,929
,, Horbury	3,977
,, Wakefield	28,069
,, Normanton	3,448
,, Methley	3,277
Ferrybridge	920
Pontefract	5,350
Knottingley	4,039
Snaith	14,644

Howden	2,315

Derwent.

Pickering	3,689
Malton (New and Old)	5,000
Helmsley	1,437
Kirkby Moorside	1,788
Pocklington	2,622
Market Weighton	2,354

Don.

Penistone	1,549
Sheffield	239,916
Attercliffe	16,574
Rother—Chesterfield	11,427
,, Dronfield	2,475
,, Staveley	2,441
,, Tinsley	953
,, Rotherham	25,892
Dearne—Barnsley	23.021
,, Darfield	1,673
,, Wath	2.023
Doncaster	18,768
Tickhill	1,844
Thorne	2,618
Crowle	3,122

HUMBER.

Ancholme or *New River*—Market Rasen	1,100
,, Caistor	2,012
,, Glandford Bridge	1,692
Barton-on-Humber	4.332
Hull River—Driffield	5,067
,, Beverley	10,218
,, Hull	121,892
Hedon	900
Patrington	1,571
Grimsby	20,244

COAST TOWNS ADJACENT.

Scarborough	22,391
Filey	2,267

K.

NAMES OF TOWNS WITHIN THE BASIN OF THE MERSEY, AND THEIR POPULATIONS IN 1871.

Goyt—Chapel-en-le-Frith	3,715
Etherow—Mottram	2,590
,, Glossop	17,046
,, Marple	4,100
Stockport	53,014
Tame—Staleybridge	21,092
,, Dukinfield	14,085
,, Ashton-under-Lyme	31,984
,, Hyde	14,223
Cheadle	2,929

Irwell.

Haslingden	7,698
Bacup	7,199
Bury	38,596
Roch—Rochdale	63,485
,, Heywood	21,248
Tange—Bolton-le-Moors	82,853
Salford	124,301
Manchester	356,626
Irk—Middleton	14.517
Medlock—Oldham	82,629
,, Altrincham	8,478
Glazebrook—Leigh	33,592

Bollin.

Macclesfield	35,450
Bollington	3,668
Wilmslow	7,861
Birkin—Knutsford	3,597
Sowbrook—Lymm	4,541

Warrington	32,140

Sankey.

St. Helen's	45,124
Prescot	5,990
Ashton-in-Makersfield	7,463
Newton-in-Makersfield	8,244

Runcorn	12,443

Weaver.

Nantwich	6,673
Whitchurch	3,696
Crewe	17,810
Northwich	2,894
Dane—Congleton	11,344
,, Middlewich	3,085
,, *Wheelock*—Sandbach	5,259
Frodsham	2,095

Branch—Tarporley	1,243

Wallasey	14,819
Wavertree	7,810
Liverpool	493,005
Bebington	6,940
Birkenhead	45,418
West Derby	27,292

L.

NAMES OF TOWNS WITHIN THE DRAINAGE AREA INCLUDING THE RIBBLE AND THE WYRE, WITH THEIR POPULATIONS IN 1871.

Ribble.

Settle	2,163
Gisburn	1,997
Clitheroe	8,208

Burnley	40,857
Padiham	6,675
Whalley	747
(*Branch*) Accrington	21,788
Darwen—Blackburn	76,339
„ Over and Under Darwen	25,154
Walton-le-Dale	8,187
Preston	85,427
Yarrow—Chorley	16,864
Douglas—Wigan	39,110
„ Ormskirk	6,127
Kirkham	3,593

Wyre.

Garstang	687
Poulton-le-Fylde	1,161
Fleetwood	4,428

M.

Names of the Towns in the Various River Basins of the Lake District, and their Populations in 1871.

Lune.

Ravenstonedale	973
Orton	1,499
Sedbergh	1,983
Kirkby Lonsdale	1,766
Bentham (High and Low)	2,237
Bolton-le-Sands	753
Lancaster	17,245

Poulton by the Sands	3,005
Carnforth	1,091

Kent.

Kendal	13,446
Milnthorp	1,599
Burton in Kendal	679

Leven.

Ambleside	1,988
Hawkshead	1,085
Ulverstone	7,607

Duddon.

Broughton-in-Furness	1,085
Dalton-in-Furness	9,310

Ravenglass	602

Ehen.

Egremont	2,377

Whitehaven	18,451

Derwent.

Keswick	2,777
Cockermouth	5,115
Workington	7,979

Maryport	7,443
Allonby	572

Wampool.

Wigton	3,425

Eden.

Kirkby Stephen	1,871
Brough	669
Appleby	1,989
Penrith	8,317
(*Branch*) Brampton	2,617
Carlisle	31,049

Liddel.

Longtown	1,946

N.

Names of the Towns on the River Basins of Durham and Northumberland, with their Populations in 1871.

Esk.

Egton	1,330
Whitby	12,460

Guisborough	5,202
Redcar	

Tees.

Middleton-in-Teesdale	2,386
Barnard Castle	4,306
(*Branch*) Staindrop	1,234
Skerne—Darlington	27,729
Yarm	1,340
Stockton	27,738
Middlesborough	39,563
Leven—Stokesley	1,877

Hartlepool	13,166
Seaham	2,802

Wear.

Stanhope	3,256
Wolsingham	7,778
Bishop Auckland	8,736
Durham	14,406
Chester-le-Street	2,450
(*Branch*) Hetton-le-Hole	7,935
Bishop Wearmouth	59,032
Sunderland	98,242

Tyne.

South Tyne—Alston	2,627
„ Haltwhistle	1,668
„ *Allen*—Allendale	5,357
North Tyne—Bellingham	833

Tyne.

Hexham	5,331
Derwent—Newbiggen	1,137
Elswick	27,801
Wallsend	4,169
Newcastle	137,665
Gateshead	48,627
Walker	8,888
Jarrow	18,179
Heworth	13,755
Howden	1,112
South Shields	45,336
Tynemouth and North Shields	38,841

Blyth.

Blyth	2,918

Wansbeck.

Morpeth	5,914
Seaton	1,590

Coquel.

Rothbury	1,074
Warkworth	765

Alne.

Alnwick	6,218
Alnmouth	469

Till.

Wooler	1,610

Belford	1,020
Berwick-on-Tweed	13,282

MISCELLANEOUS.

ADULT INSTRUCTION THROUGH PUBLIC MUSEUMS.

(Subsidised by Parliament.)

The following results, giving important information bearing on public education, are obtained as correctly as possible, from inquiry and Parliamentary returns, in the hope that they may hereafter be officially collected and published periodically, like the Registrar-General's returns. The number of visitors for the months of December, 1878, January, February, March, April, and May, 1879, are stated. When they are counted by sight the letter "S" is used, when by turnstile the "M":—

INSTITUTIONS.	Amounts voted in 1878.	Number of Visitors in December.	Number of Visitors in January.	Number of Visitors in February.	Number of Visitors in March.	Number of Visitors in April.	Number of Visitors in May.	How counted.
	£							
1. British Museum	112,990	46,709	51,475	22,219	39,373	79,496	57,640	S
2. National Gallery, Charing-cross	11,983	51,415	55,369	64,146	66,189	94,581	85,890	S
3. Kew Gardens and Museum	22,622	4,736	4,252	5,127	20,515	51,913	41,538	S
4. South Kensington Museum	39,726	68,320	51,271	56,145	70,410	105,246	67,703	M
5. Bethnal-green Museum	7,850	36,770	30,805	33,165	39,120	53,670	34,252	M
6. National Portrait Gallery, South Kensington	2,000	....	....	....	....	....	....	M
7. School of Mines and Mining Record Office, Geological Museum, Jermyn-street	8,931	2,937	2,761	3,376	3,166	2,955	3,322	M
8. Patent Office Museum, South Kensington	1,800	21,122	18,517	16,605	18,647	29,101	17,669	M
9. Edinburgh National Gallery	2,100	5,835	19,307	5,260	6,385	5,484	7,686	M
10. Edinburgh Museum of Antiquities	....	5,568	19,903	4,189	4,425	4,861	7,468	M
11. Edinburgh Museum of Science and Art	10,838	23,895	57,866	55,889	104,961	75,385	54,491	M
12. Edinburgh Royal Botanic Garden	1,750	827	1,508	2,264	4,843	7,308	14,318	M
Science and Art Museum, Dublin:—								
13. Museum of Natural History	1,762	7,216	1,229	11,496	12,548	13,444	13,107	M
14. Glasnevin Botanical Gardens and Museum	2,224	8,512	9,756	7,967	13,677	14,203	23,687	M
15. National Gallery of Ireland	2,389	3,498	5,783	6,424	6,243	5,747	8,427	M
16. Museum of Royal Irish Academy, Dublin	200	....	....	....	....	....	....	M
17. Zoological Gardens, Dublin	500	6,769	4,706	3,853	6,417	10,042	13,308	M
18. Tower of London	1,590	18,495	18,374	16,067	22,507	26,827	26,385	S
19. Royal Naval College, including Greenwich Painted Hall	38,051	19,329	17,687	19,275	23,735	42,753	31,122	S
20. Royal Naval Museum, Greenwich	1,055	2,056	1,747	1,634	2,404	10,123	4 688	S
21. India Museum, South Kensington	....	1,331	1,067	838	1,283	2,793	1,956	M
22. Hampton Court Palace	7,475	....	....	....	....	....	....	..

(1) Return refused. Open Mondays, Wednesdays, Fridays, and Saturdays. Closed, except to students, on Tuesdays and Thursdays.

(2) Open Mondays, Tuesdays, Wednesdays, and Saturdays. Closed on Thursdays and Fridays. Open on 19 days, in December, from 10 to 4 o'clock. Total of the year 1878—188 public days—902,162. Open, in January, 17 days, from 10 to 4; February, 16 days, from 10 to 5; March, 18 days, from 10 to 5; April, 16 days, from 10 to 5; May, 17 days, from 10 to 6. Total of five months, 366,175.

(3) Open on Sundays and week days.

(4) Open morning and evening till 10, on Mondays, Tuesdays, and Saturdays. Students' days—Wednesdays, Thursdays, and Fridays, 6d. entrance; open from 10 till sunset.

(5) Ditto.

(6) Return refused. Open daily, except Sundays.

(7) Open daily, except Sundays and Fridays, and in the evenings till 10 of Monday, Tuesday, and Saturdays.

(8) Open daily, Sundays excepted.

(11) Open daily (10 a.m. to 4 p.m.) except Sundays, and Friday and Saturday evenings (6 to 9). Students' days—Monday, Tuesday, and Thursday; admission 6d.; other days, admission free. Total number of visitors during year 1878, 398,183.

(12) Total number of visitors to the Gardens during the year 1878, 88,667.

(13) Open daily, and in the evening.

(14) Open daily, including Sundays.

(17) Open daily, including Sundays.

(18) Open daily, except Sundays. Boxing Day a free day, 1878, for first time.

(19) Open daily, including Sundays.

(20) Open daily, except Fridays and Saturdays.

(21) Paid for by Indian Government. Open on Mondays, Tuesdays, Fridays, and Saturdays, 1d. admission; on Wednesday and Thursday, 6d. admission.

(22) Open on Sundays, and on week days except Fridays.

INDIA MUSEUM.

In the House of Commons on the 17th inst., **Mr. Wait** asked the Under Secretary of State for India, whether, in view of the forthcoming abolition of the India Museum, and the disposition of its contents, he will be prepared favourably to consider applications from provincial museums connected with schools of art for portions of the collection. **Mr. Wilbraham Egerton** also asked whether, before the Secretary of State for India finally decides on the dispersion of the India Museum, he will state to the House what is proposed to be done with the various portions of the collection—and, whether he will have any objection to lay upon the table any memorials relating to the establishment in London of an India Museum, addressed to her Majesty's Government by the Association of Chambers of Commerce of the United Kingdom, and by the Chambers of Commerce of Manchester, Liverpool, Bradford, Birmingham, and Glasgow; or any other documents bearing on the subject.

In answer to these questions,

Mr. E. Stanhope said—The Secretary of State in Council has finally decided on the removal of the collections now in the India Museum for the reasons I stated the other day, and a committee has been appointed to consider the details of the arrangement. The important subject raised by my hon. friend the member for Gloucester—namely, applications from provincial museums connected with schools of art for portions of the collection—has been specially referred to it, and I can assure him it shall not be lost sight of. With regard to those portions of the collection in which my hon. friend the member for Cheshire is specially interested, and as to which his advice would be of the greatest value, I hope he will consent to put himself into communication with the committee. There is no particular objection to the production of the memorials mentioned by my hon. friend, except that it would appear to involve a very useless expense, as they have already been printed and made public, and refer to wholly different proposals from those which are now made.

Mr. Jenkins asked whether, before the dispersion of the collection, an opportunity would be given the House to consider the subject.

Mr. Rathbone asked whether, before the dispersion, an opportunity would be given the large towns to see the collection in its entire state.

Mr. E. Stanhope said he was afraid he could not give the engagement the hon. member for Dundee asked for, because it would involve the postponement of the matter until next Session, and would impose additional expense on India. With regard to the question of the hon. member for Liverpool, he did not see how it was possible to send round to the large towns the whole of the collection. In any case, if what the hon. gentleman asked was done, it should not be at the cost of the revenues of India.

WATER SUPPLY EXHIBITION.

The *Times* announces that it has been decided to hold an exhibition at the Alexandra Palace, the lessees of the Palace having given the committee formed for the purpose the use of their "Exhibition Court" (200 ft. by 100 ft.) The object of the proposed exhibition is to bring together a collection of plans, diagrams, models, apparatus, &c., which shall illustrate all the considerations that have to be regarded in arranging water supplies. The exhibition is arranged in the following sections:—(1) The physics and chemistry of water; (2) rainfall (including tables of periodical averages); (3) catchment basins, with apparatus for studying percolation and evaporation, current meters, &c.; (4) geology and hydro-geology (including well-measuring apparatus); (5) waterworks and filter beds, well sinking and boring apparatus) (6) distribution of water—pipes, taps, and household appliances, waste preventers, &c.; (7) water examination—chemical analysis, microscopic examination, and examination of clearness; (8) filtration—cistern, table, and pocket filters; (9) hardness in connection with washing, cooking, brewing, and tea and coffee making; soaps in connection with washing; and methods for testing and lessening hardness; (10) water in connection with the spread and origination of disease; (11) antiquarian illustrations; (12) statistical tables; (13) pollution and its prevention; (14) literature; (15) artificial aërated waters and cooling appliances. Information respecting the committee and its proposals will be given on application to Mr. A. T. Atchison, 34, Great George-street; and the manager of the Alexandra Palace will give information about the exhibition. No charge will be made for space to exhibitors. The *Times* remarks that—"The proposal for the museum is one of the outcomes, unexpected perhaps, of the Conferences held by the Society of Arts on water supply at the wish of the Prince of Wales. While the Conferences urged a Commission to advance our knowledge, it was recognised by some that a spread of our present knowledge would do much good, and a central museum, which might be imitated in other towns, was regarded as one of the most ready ways of accomplishing this. It will remain for the committee to decide what of the contributions to the exhibition should be included in a permanent museum."

EXPERIMENTS ON THE FLOW OF SOLIDS.

The following memorandum of the researches of Mons. Tresca is by Mr. Chandler Roberts, F.R.S., chemist to the Mint:—

"The relation which the raised portions of the obverse of a coin should bear to those on the reverse, though of much importance, is often neglected by artists, and sometimes by skilful engravers, whose designs on separate dies are, in consequence, imperfectly represented or even distorted when the dies are employed simultaneously to produce impressions on the two sides of a metallic disc. As any theoretical facts which bear directly on this question must be of much practical value in coinage, I may perhaps be permitted to direct attention to some recent experiments by M. Tresca, sous-Directeur du Conservatoire des Arts et Métiers of Paris, on the 'flow of solids.' He has shown that, when metals are submitted to compression, they so closely resemble fluids in their behaviour, that the shape they will assume can be deduced by calculation. It is even possible to lay down the trajectory of the molecules of the compressed metal, and to establish with certainty the final places they will occupy as compared with their initial positions; it follows, therefore, that the final position of any line or surface may be predicted. In stamping, the pressure is found to be gradually transmitted from one zone or layer of the blank to another, in absolutely the same manner as in the flow of liquids, and with a regularity not less remarkable, although following a much more rapid law of diminution. The engraved work on the die forms in fact a series of channels designed to facilitate the flow of the metal of which the coin or medal consists, and to guide it in the required directions. In the compression of a blank between dies, the portions not to be brought into relief by the action of the press are reduced in thickness for the benefit of the neighbouring raised portions, the metal literally flowing radially from the level parts to the reliefs. This flow is of course gradual, and the presence of scars sometimes seen on medals in high

relief may be traced to the junction, during the later strokes of the press, of projections formed in the earlier stages. With such facts in view, M. Tresca has shown that it may sometimes be useful to distribute the flow of the metal by centripetal instead of vertical compression. It is to be hoped that these experiments will be continued, as the results appear to afford a scientific basis for an art which must always depend greatly on technical skill and individual experience."

THE MINT.

The ninth annual report of the Deputy-Master of the Mint has just been issued, from which the following is an extract:—

In consequence of the continued depression of trade, the demand for coin during the year 1878 has again been below the average, and for the first time since 1870 the Mint has been able itself to meet all demands for imperial coin, and to undertake the execution of the colonial coinages required, without having recourse to contracts with private firms. It is unnecessary to state that even the limited amount of work devolving upon it has been sufficient to keep the machinery of the department in constant occupation.

The coins struck during the year 1878 were of 22 different denominations. The total number of pieces struck at the Mint was 24,491,230, as against 30,131,130 in 1877, and their value, real or nominal, £2,785,790 6s. 2½d.

The total number of British coins struck during the year was 22,823,230, and their value as follows:—Gold, £2,132,245 10s.; silver, £614,426 11s. 10d.; bronze, £18,664 1s. 0½d.

The coinage of gold, as will be seen from the above statement, but slightly exceeded £2,000,000, of which one-half consisted of half-sovereigns, notwithstanding that the number of sovereigns from the Sydney and Melbourne branches of the Mint received by the Bank of England during the year was only £2,773,000, or less by nearly a million than the amount received in 1877. It is clear, therefore, that the smallness of the demand on the Mint for gold coin, which has now continued for three years, is due to the general contraction of trade rather than to any large and increasing supply of sovereigns coined in Australia.

No light gold coin was sent in by the Bank of England for recoinage during the year, but nearly the whole of the gold coinage which was commenced in November, 1877, and of which the coinage of 1878 was a continuation, was from light gold, and during the two years, therefore, out of a coinage of £3,230,986, £1,557,500, or nearly one-half, consisted of worn coin withdrawn from circulation.

The coinage of silver has been comparatively large, notwithstanding the fact that an unusually large quantity of worn silver coin has been withdrawn from circulation during the year. The amount coined was £614,426, as against £407,822 in 1877, and of this sum £567,328 was issued to the public.

The issues consisted of £215,500 to the Bank of England, £156,200 to the Bank of Ireland, £41,000 to Scotch banks, £69,950 to the Colonies, £74,250 for Treasury chests abroad, and £10,075 in threepenees supplied direct to private applicants. The total amount of the latter coins issued was £30,425, as against £30,115 in 1877, and was again reduced, as in the two preceding years, by an arrangement under which persons applying for small sums were referred to a banking company holding a larger stock than it required for its own use.

Half-crowns of the nominal value of £132,700 have been issued during the year, and the total amount of these coins issued since 1874, when it was decided to resume their coinage, has thus been raised to £675,600.

The issues of bronze coin amounted to £39,205, as against £42,050 in 1877. Of this amount, £26,530 consisted of pence, £8,502 of halfpence, and £4,055 of farthings, so that the issue of pence was considerably less, while that of halfpence and farthings was rather larger, than in 1877. This result is to be accounted for by the fact that from January to November the issue of pence was suspended in the metropolitan district, and applicants were referred, as on former occasions, to brewing firms in London who had intimated that they held stocks in excess of their own requirements. The shipments of bronze coin to Colonies, and in aid of Treasury chests abroad, amounted to £5,400, as against £8,040 in 1877, the principal consignments being £2,000 to the Melbourne Mint for issue in Victoria, and £1,205 to South Australia.

Notwithstanding the decrial of the old copper coinage in 1869 and their Lordships' decision, of which due notice was given to persons who had been in the habit of collecting the old coin, that it could not be received at its full nominal value after the 30th of July, 1873, applications have continued to be received, even during the past year, from tradesmen and others, residing chiefly in country districts, to be relieved of trifling amounts of copper coin remaining in their hands. Some of the applicants appeared to have collected pence of a particular reign or year, under the mistaken impression that the coins possessed some special value, but it was necessary to reply to all such requests that copper coin had, under proclamation of the 13th of May, 1869, ceased to be legal tender from the end of that year, and could not be received at its nominal value. Such applications afforded additional evidence of the length of time required for the complete withdrawal of a large coinage which has been for many years in circulation.

On the 5th of November, a request was received from the Government of Malta for a coinage of £100 in the small bronze pieces of the nominal value of one-third of a farthing circulating in that island, and this coinage, consisting of 288,000 pieces, was executed by the Mint in the month of December.

A bronze coinage was executed and shipped to Cyprus in the month of March. The total number of pieces struck was 650,000, of which 250,000 were piastres, 250,000 half-piastres, and 150,000 quarter-piastres. The nominal value of the coinage was £2,291. The obverse of the coins bore the effigy of her Majesty, with the words "Victoria Queen," and the date, and the reverse the large numerals "1," "½," "¼," with the words "Cyprus," and "one piastre," or "half piastre," or "quarter piastre," as the case might be, above and below them.

ARTIFICIAL DIAMONDS.

The production and manufacture of imitation precious stones, says the *English Mechanic*, always considerable, has been rapidly increasing in France of late years, and at the present time, owing to the perfection at which the art has arrived, the demand greatly exceeds the supply. The chief seat of the manufacture is supposed to be Paris, but this is a popular error. The dealers carry on business in that city, but the artificial stones are manufactured in the mountains of the Jura, Franche-Comté, the communes of Sainte Claude, Septmoncel, la Meure, les Molunes, and the surrounding districts. The inhabitants, men, women, and children, are entirely engaged in the production of these stones, and have been so for generations past. They particularly excel in the cutting of artificial diamonds. At the present time this species of industry has developed into a great resource for the inhabitants of the above districts, and they positively neglect the cultivation of the land in its favour. Certain of them undertake the cutting of real stones, but in this, as a whole, they cannot approach

the careful workmanship and execution of the Paris lapidaries.

At the present day, a special composition, possessing a considerable refractive power, serves exclusively as a base for artificial diamonds and other precious stones. This product is called strass. It differs from glass by the presence of about fifty per cent. of oxide of lead comprised in its elements. The name is derived from that of a workman named Stras, who, in the last century (about 1762) first directed attention to the composition, and is credited with being the inventor.

At the present time strass consists of the following:—

Silica	38·2
Oxide of lead	53·0
Potash	7·8
Alumina, borax, arsenious acid	traces

The ingredients and substances composing modern strass are doubtless the same as those employed in the Middle Ages, and it is probable that their proportions differ but slightly. But modern chemistry provides the manufacturers of our day with products of perfect purity, and the *modus operandi* has become greatly simplified. The procedure of the early makers was prodigiously complicated. They were, nevertheless, aware of the fact, confirmed by modern experience, that the longer the fusion was continued the more beautiful the strass became. When the substance is produced perfectly pure, it serves to imitate all precious stones. It is remelted and intimately incorporated with substances having metallic bases, generally oxides, which, by their combination with the elements of the strass, communicate to it divers colours. Imitation sapphires are produced by 1,000 parts of strass and 25 of oxide of cobalt. Emeralds, by 1,000 parts of strass, 8 of oxide of copper, and 0·2 of oxide of chromium. Diamonds being colourless, pure strass alone is employed, cut in the form of a brilliant or rose. By a recent improvement in the process for making these last-named stones, a preparation of gold is substituted for the oxide of lead in the composition of the strass.

THE FORESTS OF FINLAND.

Consul Campbell states that the produce of the forests in Finland supplies more than one half of the total export of the country, it is therefore apparent of what infinite importance the proper husbanding of them must be to the welfare of the Grand Duchy. It is estimated that 64 per cent. of the total superficial area of the country, or, in other words, 213,722 square kiloms., are covered with timber; unfortunately, however, these enormous resources have much deteriorated during the last fifty years. The system of setting fire to the trees, in order to clear the ground, is still practised in many districts of the country on a large scale, and the conflagrations thus originating sometimes assume great proportions; new laws and regulations, however, lately put in force have contributed in some measure to modify the evil. Another cause of ruin to the forests is the system of burning the pine trees to obtain tar, and the third cause is the annual destruction of millions of young trees hewn down for the purpose of making palisades round the buildings and fields.

According to the report of a commission lately appointed to make an approximate calculation of the Government forests, it appears that no less than 754,000,000 cubic feet of wood are actually absorbed in Finland annually, without taking into account the quantity consumed in the town, nor that exported from the country. It must, however, be admitted that this state of things has somewhat improved since the means of communication have progressed, and the value of timber advanced to a price which it never previously commanded; this last-mentioned circumstance has, however, unfortunately, been the means of inducing the forest owners, tempted by the high prices, to dispose of their property to the saw-mill proprietors, whose interest naturally lies in taking out of the forests as much as possible, without respect to the age or size of the trees. This question is at present engaging public attention as well as that of the Government, and, doubtless, if it is not discontinued, measures will be adopted to put a stop to this wholesale destruction of timber.

The researches lately instituted to ascertain the time necessary for development of trees in various parts of the country show the following results. In the south of Finland, 61° 30′ latitude, the pine forests in good soil yield building timber in 60 years; on middling soil, in 80 years, and on indifferent soil, in 100 years. To be suitable for sawing purposes, the pine tree requires to attain the age of 100 to 140 years. In the middle districts of Finland the growth of timber is twenty years longer under like circumstances. Lastly, in the northern districts, the pine trees require from 120 to 180 years to develop themselves so far as to be serviceable for building timber, and 180 to 230 years before they can be used for sawing purposes.

Notwithstanding the enormous abuse of timber previously alluded to, Finland is a country still rich in forests, for which she has to thank, in the first instance, a most propitious climate, and a sun particularly favourable to the growth of timber; and, in the second, to the fact that more than one-half of the surface of the forests is the property, and under the control, of the Crown. In fact, the Crown forests, after deducting the territory occupied by lakes and morasses, cover a superficial area of 131,500 square kilomètres, the greater part of which lies in the northern districts of the country. The administration of the forests is entrusted to a directorate, whose seat is in Helsingfors, and who has under its control eleven forest chiefs, and a great number of under officials. It is not many years since the cutting of timber was accomplished by the peasants, during the winter months, by means of the hand-saw, and now we find large saw mills, driven by both steam and water power, at the estuaries of all the great rivers, and at the various waterfalls throughout the country. At present, the saw-mill proprietors prefer purchasing their stock from private parties rather than from Government; but, doubtless, this will soon change, since the Crown has determined to spend a large amount of money in clearing the water-courses around their forests, and in every way improving the means of transit and floating.

CORRESPONDENCE.

MR. HUTCHINSON'S PAPER ON AFRICA.

The paper entitled "The Contact of Civilisation and Barbarism in Africa, Past and Present," by Mr. Edward Hutchinson, contains much interesting information of an historical character, but it is to be regretted that the author should form such a desponding opinion as to the indefinite length of time which he considers inevitably requisite for the introduction of civilisation in Africa. This is to be regretted all the more, inasmuch as Mr. Hutchinson, from his position as the lay secretary of the Church Missionary Society, is naturally looked upon as a great authority on all matters connected with Africa. Mr. Hutchinson remarks:—"In considering the various instances of the contact of civilisation with the barbarism of Africa, I think we shall be struck at the outset with the fact, that, whereas in every other part of the globe civilisation, by mere contact, apparently has planted offshoots which reproduce not

only its vices but also its virtues, the soil of inter-tropical Africa seems incapable of receiving or nourishing the better germs of civilisation." Mr. Hutchinson then goes on to tell us what the civilising agencies have been, which should, in his opinion, have produced better results. They are the ancient and modern Egyptians, the Carthaginians, the Romans, the Moors, Arabia, Portugal, France, Holland, and England. The civilisation of these countries, as described by Mr. Hutchinson, we find on analysis, could be more correctly called "civilised barbarisms."

Apart from the noble efforts of the self-sacrificing Christian missionaries, sparsely dotted here and there over the continent, these children of Nature have never yet come in contact with civilisation, have never yet had fair play, and, therefore, it is premature to form an opinion as to the victories or otherwise awaiting true civilisation in the regions about which Mr. Hutchinson has formed such pessimist views. It is somewhat difficult to follow the abstruse arguments given in Mr. Hutchinson's paper. Quoting Mr. Buckle and Mr. John Stuart Mill as his authority, Mr. Hutchinson says that "in the formation of society, wealth must accumulate before knowledge can begin, and that of all the great social improvements the accumulation of wealth must be the first, because without it there can be neither taste nor leisure for that acquisition of knowledge on which the progress of civilisation depends," and yet at the close of his paper Mr. Hutchinson states, "As a general conclusion, not only do I think that no large mercantile scheme will prove remunerative in Central Africa, I believe that the success of such a scheme would not tend in the least to promote the civilisation of the people." As Mr. Hutchinson assents to the principle laid down by Buckle and Mill in one part of his paper, it appears to me that he expresses his disbelief in their principle in another part of the same paper, as it is difficult to understand how wealth can be accumulated in a savage or primitive stage, or, indeed, any other stage of society, without the operation of trade or commerce coming into play. Mr. Hutchinson then goes on to state that "the progress towards civilisation must be very slow, and the first germs of civilisation must be planted by men of science, or the philanthropists, or the Christian missionary, both by precept and example. It is the lives and examples of such men as Livingstone, Speke, and Grant, and of those other travellers and agents of missionary societies who would be content to exhibit to the negro the quiet nature, patience, and gentleness, and power of restraint, which characterise these men, that will do most towards planting true civilisation amidst the barbarism of Africa." Now, none can dissent from the beneficial effects of a life such as Livingstone's, spent amidst the tribes of Africa, but such agencies, in relation to the vast continent of Africa, are only as a drop in the ocean, and if we must be content to trust to the civilising of all Africa by such means, its complete civilisation will be achieved with the advent of the millennium. It is a pity that Mr. Hutchinson is negatively opposed to commerce, and is so wedded to the conviction that the success of large commercial operations in equatorial Africa will not promote the civilisation of the people. Has it ever occurred to him that a new era may be introduced in the regions concerning which he takes such gloomy views, by the introduction, through means of a large trading company, of young men selected for their business capacity and high moral character, for the purpose of working a number of trading stations placed at all convenient points? Such men, "being true and just in all their dealings," and many of them, probably, largely endued with the spirit of Christianity, which would lead them to give a helping hand for the elevating of the tribes with which they come in contact, would prove the most effectual co-operators with the Christian missionary, whose especial work it is to deal with the conversion of those amongst whom he labours. I am sorry to see that Mr. Hutchinson, in a somewhat uncalled-for manner, refers to my scheme for forming a large company, and refers to the large amount of capital which I advocate as necessary. If he cannot help, or approve of the scheme—its object and intention being good—why should he oppose it? I may tell him that, if the company which I am strenuously labouring to form should see daylight, its articles of association will strictly prohibit abuse in the introduction of arms and spirits. As I am a supporter of the Church Missionary Society, I shall not be accused of indifference to the grand work it is doing all over the world, but I contend that the introduction of railways, telegraph-wires, and steamers, are quite as important pioneers of Christianity as the most devoted body of missionaries the Church Missionary Society ever sent out, and that these agencies can no more be brought into operation without the sinews of war than can the Church Missionary Society conduct its large operations without the money which is needed. Mr. Hutchinson complains of the apathy of the English Government, and of its neutrality where interference should take place from time to time; nay, of its positive prohibition at times of steps which others would have taken. In the scheme which I advocate, all this is considered, and if we had about fifty thousand shareholders in the intended African Trading Association Limited, from all towns of the kingdom, a moral pressure could through such an organisation be brought upon the Government of the day whenever requisite, which could not easily be withstood. That is one reason why I am striving to induce the working classes of Lancashire to take an interest in this scheme by becoming shareholders. I may say that they are beginning to take the matter up in good earnest. A meeting was held in February in Preston by the trades societies, at which three to four thousand people were present, followed by a crowded meeting in March in Blackburn, over which the Mayor of Blackburn presided, and in the course of the next few weeks a large meeting of trade societies will be held in Rochdale, over which the Mayor will preside, all for the purpose of giving support to legitimate efforts to throw open Africa to commerce. Lancashire has done more than any other county to support the slave trade in the past. She has yet a great debt to wipe off by way of atonement for her sins against the negro, inasmuch as she remained content, until the American Civil War, to take her chief supply of raw material from the slave grown cotton of the Southern States, and it is now becoming generally recognised in Lancashire that Africa must become our future great market, if Lancashire's spindles and looms are to be kept at work, and employment found for hundreds of thousands of operatives.

James Bradshaw.

8, King-street, Manchester,
June 23rd, 1879.

PATENT LAW.

Sir,—It is a great pity, in the race with the United States, the Briton should be so heavily handicapped; he ought, at least, to have fair play, and to be regarded as a saver of labour and hence a benefactor. But how is he to do so with the heavy tariffs, the difficulties of redress, and great cost of registering after improvements, so readily accorded in most other countries?

In England the Crown, which is so suspicious of fraud from patentees, commits daily a grave error, an error unworthy of the State, that often leads the public, whom they seek to enlighten, astray. For example, an invention has provisional protection accorded to it, *ad interim*, that is to say, before the expiry of six months. The inventor either sees or invents something more; this he registers also, embodying both afterwards in one patent. At the expiration of six months (and about six

weeks) the original specification is printed, with the words upon it, "This invention received provisional protection only," and this when the Patent-office has duly sealed the same, a most misleading transaction and unfair to the public, who naturally are deceived; in fact, it is false: the invention is secure, and the Patent-office authorities ought to make that known upon the document they sell, and which they will deny should it be brought into a court of law.

There is another great wrong; it is the abuse of the word "patent," so often applied to things not patented or worthy of being secured. This should be a default and punishable, as also the placing of the word "patent" upon an article possibly secured in another country, but either imported or manufactured in this, and too often a contrefaction of an English patent that has paid its heavy tax, and which it undersells.

Patents at a modest price, with an easy means of redress, would do much to advance industry and to stimulate that inventive faculty our Patent-laws have done their best to hinder, because quite beyond the purse of most mechanicians. John Leighton.

Regent's-park, June 29th, 1879.

NOTES ON BOOKS.

The School Cookery Book. Compiled and edited by C. E. Guthrie Wright. London: Macmillan and Co. 1879.

This little manual by Miss Guthrie Wright, the hon. sec. of the Edinburgh School of Cookery, contains a large amount of useful matter in a small space. It is divided into two parts—1, theoretical; 2, practical. In the first, the science of food and its adaptation to the human body is explained in clear language, and in the second, are a collection of receipts and directions to the cook how to proceed in putting these into practice. An appendix contains suggestions for arranging cookery classes in elementary schools.

The Students' Text-book of Electricity. By H. M. Noad, F.R.S., &c. New Edition, revised by W. H. Preece, M.Inst.C.E., &c. London: Crosby, Lockwood and Co. 1879.

The preface to the first edition of this book is dated 1866, and a supplementary note to it adds that while the work was passing through the press, the 1865 Atlantic cable had been recovered, and the 1866 cable laid. The advances made since then in electrical science are obviously such as to have made much of this well-known text-book out of date, and necessitate a fresh edition. In his work as editor, Mr. Preece has evidently been anxious to preserve as much as possible of the original, and the modifications in the text take the form of additions rather than alterations. All the earlier portions of the book seem the same, a few additions being made here and there, frequently in the form of quotations from established authorities—Mr. Fleeming Jenkin, Sir William Thomson, and others—required to bring the information up to date. The first fourteen chapters in this edition are the same as in the earlier one, but when we get to the fifteenth chapter, which deals with magneto-electricity, there is evidence of the progress made in the last few years by the science. In 1866 there was only the Holmes machine to describe, the Alliance machine being referred to as "a machine originally intended for the production of illuminating gas by the decomposition of water," which was shown by Shepard at the 1862 Exhibition, but "could not be worked at a profit as a gas generator." In the concluding chapter also, Wilde's paper before the Royal Society (1866) is referred to under the heading, "A New and Powerful Generator of Dynamic Electricity," a heading which is retained in the new edition, though the paragraph itself is transferred to its proper position in the part of the book devoted to electric generators. Now we have, of course, the machines of Wilde, Siemens, Gramme, and the others, of which we have recently heard so much. These, as well as the machines of Ladd and Tisley, and the Alliance Company's machines, are all now described. There does not, however, appear to be any reference to the various machines for dividing the current, or any mention of the machines of Lontin, Brush, De Meritens, Wallace and Farmer, and some of those other inventors who have recently been working in the same direction. But the part of the book in which the greatest alteration will be looked for is in that relating to telegraphy, and here we find very large additions. In fact, 150 pages are devoted to this part of the subject, whereas in the original edition there were only 62. A whole chapter is given to the telephone and microphone, the instruments of Reis, Varley, Gray, Bell, and Edison (the carbon transmitter) being described, and, of course, Prof. Hughes' microphone. Another new chapter is devoted to the electric light, the chief lamps described being those of Siemens, Rapieff, Regnier, Wallace, Way (vein of mercury, 1856), Jablochkoff, and King (incandescent carbon, 1845.) In the first edition, Holmes and Duboscq's lamps only were described.

A Ministry of Health, and other Addresses. By B. W. Richardson, M.D., F.R.S., &c. London: Chatto and Windus, 1879.

Under this title, Dr. Richardson has re-published several of his addresses, together with articles which have appeared in some of the magazines, and treat of allied subjects. The paper on the "Ministry of Health" is a production of Dr. Richardson's address to the Sanitary Institute, last October, of which Institute he was then, as he is now, the President of Council. Beginning with an argument as to the necessity for some central organisation in sanitary matters, it passes on to a careful examination of the sort of organisation which is required, and which would be accepted by public opinion as it now exists. After this, it proceeds to suggest the practical form which such a ministry—consisting of a President and an acting Board of Health—might take; the duties it could fulfil; the organisation it would require. The second essay is a sketch of the life and work of William Harvey, combined with a vigorous defence of his claims to be considered the dicoverer of the circulation of the blood, against those put forward on behalf of Fabricius, Cæsalpinus, and others. Another essay on "Burial, Embalming, and Cremation," will possess special interest for readers of this *Journal*, inasmuch as it is in part an elaboration of the opening portions of the first lecture of the course recently delivered by Dr. Richardson before the Society upon "The Preservation of Animal Substances." The conclusions at which Dr. Richardson arrives are not wholly favourable to cremation, on the ground that it decomposes the animal tissue into its ultimate elements, instead of merely resolving it into less complex compounds, such as result from the slower processes of putrefactive decay. Thus, instead of ammonia being produced for the benefit of vegetable life, we have the elements, nitrogen and hydrogen. It is probably rather a fresh view to take of the subject to argue that we are depriving the earth of that tribute we owe her by thus dissolving our bodies into their elementary constituents, instead of handing them over to her, that she may utilise them in more gradual processes of separation and decay. The "World of Physic" is an inaugural address at one of the sessions of the St. Andrew's Graduates Association. It treats of the relation of the profession of medicine to the world

at large. "Learning and Health" is to some extent a protest against the modern style of education, and especially against its extension to the female sex. The last two, "Registration of Disease," and "Ether Drinking and Extra-Alcoholic Intoxication," treat of subjects which Dr. Richardson has specially made his own, both of which, also, he has dealt with more or less directly before audiences of members of this Society.

Town and Window Gardening, including the Structure, Habits, and Uses of Plants.—A course of sixteen lectures by Catherine M. Buckton. London: Longmans, Green, and Co., 1879.

This little book owes its existence to the success of the author's attempt to foster the love of gardening among the children of the Leeds Board Schools. Finding from experience that window gardens are very difficult gardens to manage, and that it is impossible for children or men to become good gardeners unless they understand the structure, nature, and growth of plants, she prepared these lectures on the elements of botany. Beginning with the seed, stem, bud, leaf, and roots, the author passes on to the consideration of fruits and flowers, and ends with an account of mosses, lichens, and seaweeds. A few hints as to the plants suitable for windows and towns are added.

Copyright and Patents for Inventions; Pleas and Plans for Cheaper Books and Greater Industrial Freedom.—Compiled by R. A. Macfie, of Dreghorn, F.R.S.E. Vol. 1. Copyright. Edinburgh: F. and T. Clark.

This volume consists of a large number of extracts from the evidence given before the Royal Commission on Copyright, besides various books and speeches, all of which are intended by the compiler to show the evils of the present law of copyright and the advantages to be gained by the adoption of a system of "royalty republishing."

Analytical Index to the Series of Records known as the Remembrancia, preserved among the Archives of the City of London, A.D. 1572-1664. London: E. J. Francis and Co.

In the Town Clerk's Record Room is preserved a valuable series of MSS. bound in nine volumes, which contains copies of the correspondence between the sovereigns of this country, their Ministers, the Privy Council, the Lord Mayors, Courts of Aldermen and Common Council, and many persons of distinction, upon matters relating to the government of the City, its rights, privileges, usages and customs, religion, trade and commerce, public buildings, markets, churches, &c. This set of books has been carefully analysed, and the entries arranged in alphabetical order under the several headings of the subjects to which they relate. Among these are numerous entries relating to buildings, education, fires, fuel, lighthouses, provisions, sewers, trade and merchandise, and water.

GENERAL NOTES.

Musical Education.—"Dr. Hullah's paper, on the great question of how a sound knowledge of music may be best disseminated, will be carefully read, not only by musical students, but by many who are not, but would gladly be, students of music. Dr. Hullah considers the best way of making musical skill common is by having it taught in the nursery and infant schools. Here we quite agree with him. Music, to some extent, should be made as much a part of primary education amongst us as it was among the Greeks. It should be added, however, that Dr. Hullah defines a musician to be one who knows, without even having heard it, the effect of what he sees written in musical characters or hears described, and, *vice versa*, to be able to write or describe that which he hears. We also agree with Dr. Hullah in considering the present system of musical notation as the best existing."—*Westminster Review*, July, 1879.

Parkes Museum of Hygiene.—At the public opening of the Parkes Museum of Hygiene, in University College, Gower-street, on Saturday, June 28th, by the Right Hon. R. A. Cross, M.P., Dr. Poore read the report of the Executive Committee, from which it appears that, up to the present time, the subscriptions amount, in round numbers, to £1,100, of which £600 has been invested in the names of trustees, in order to form an endowment fund. The committee have attempted to illustrate visually the various subjects which are treated of in Dr. Parkes's comprehensive book on "Practical Hygiene." The articles exhibited are arranged in six groups, under the headings of—1. Engineering; 2. Architecture; 3. Furnishing; 4. Clothing; 5. Food; 6. Preservation and Relief. Attached to the museum is a library, and a descriptive catalogue of both museum and library has just been issued.

Heslop's Winding and Pumping Engine.—This interesting old engine, which was originally erected about the year 1795, for the purpose of raising coals at Kell's Pit, near Whitehaven, has been presented to the Commissioners of Patents by the Earl of Lonsdale, and is now deposited at the Patent Museum. It continued in use at Wreah Pit, also near Whitehaven, until the summer of 1878, when it was removed to London, and it is now the only engine of this type in existence. The engine has two open topped cylinders, one on each side of the main centre of the beam, and both single acting. These cylinders are respectively the "hot cylinder" and the "cold cylinder." The steam, on being admitted into the first, or "hot" cylinder, raises the piston by its pressure underneath; the return stroke is then made by the weight of the connecting rod and by the momentum given to the fly wheel. The eduction valve being now open, the steam passes from this cylinder to the second or "cold" cylinder by means of the connecting pipe which, being constantly immersed in cold water, produces sufficient condensation to "kill" or reduce it to atmospheric pressure as it enters and fills the cold cylinder. The cold piston having arrived at the top of its stroke, and its cylinder being thus filled with steam, and the injection valve being now open, a jet of water is admitted, thus bringing a vacuum into play. By this arrangement of two cylinders Heslop obtained advantages closely approaching those of the separate condenser, and effected a signal superiority over the atmospheric engine of Newcomen, even as it then existed with all the structural improvements introduced by Smeaton, who was compelled to admit that, in its best state, 50 per cent. of steam was wasted by alternate heating and cooling of the cylinder.

Jamin's Electric Lamp.—Among the various forms of electric lamps recently produced is one by M. Jamin. It consists of two nearly parallel carbon rods, surrounded by an elliptical coil of wire, through which the current passes. It is this arrangement of the conductor in the shape of a coil around the rods that forms the novel part of the invention, and gives rise to the phenomena witnessed. The coil, being in the same vertical plane as the carbon rods, is arranged so that the current through it is in the same direction as that which flows through the latter, producing the arc at their extremities. In virtue of the law that currents in the same direction attract and those in opposite directions repel each other, the currents through the upper portion of the coil will attract the arc, and those through the lower portion will repel it. The lateral currents also, by reason of their tendency to deflect the arc into parallelism, aid in repelling the latter to the extremities of the carbons. So powerful is this effect of repulsion that, if the number of turns of wire in the coil be too great, the arc, if caused to pass between the lower portions of the carbon rods, will move upward with great velocity, and the light becomes extinguished, owing to the arc being too strongly attracted in the direction of the extremities of the carbons. With this apparatus the arc becomes strongly curved; and it is stated that the light evolved is very considerably augmented by its use, owing to the carbons being no longer consumed laterally, so as to shade the light. By using this apparatus, also, the lamp may be inverted, without any danger of the arc quitting the extreme ends of the carbon rods.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

NATIONAL WATER SUPPLY, SEWAGE AND HEALTH.

The report of the Conference held in May last is now ready, and can be obtained at the Society's House, price 1s. 6d. paper, 2s. boards with cloth back.

"OWEN JONES'" PRIZES, 1879.

This competition was instituted in 1878, by the Council of the Society of Arts as trustees of the sum of £400, presented to them by the Owen Jones Memorial Committee, being the balance of the subscriptions to that fund, upon trust to expend the interest thereof in prizes to "Students of the Schools of Art who, in annual competition, produce the best Designs for Household Furniture, Carpets, Wall-papers, and Hangings, Damask, Chintzes, &c., regulated by the principles laid down by Owen Jones." Each prize consists of a bound copy of Owen Jones' "Principles of Design," a Bronze Medal, and such a sum of money as the fund admits of.

The prizes are awarded on the results of the annual competition of the Science and Art Department.

The following is the result of the competition for the present year:—

1. T. W. Bradburn, School of Art, Coalbrookdale—Design for a Mosaic.
2. Mary Denley, St. Mary's School of Art, Westminster, S.W.—Design for a Carpet.
3. Joseph Castle, School of Art, Grammar School, Manchester—Design for a Chintz.

REPORT OF EXAMINATIONS COMMITTEE.

The following report was adopted at the meeting of the Council, July 21:—

The Examinations of the Society of Arts were established in 1856, in which year 52 candidates were examined in the Society's House. In the following year, 1857, the first attempt at provincial examinations was made, and an examination was held at Huddersfield, as well as in London, the Examiners of the Society going down for the purpose. The desire of increasing the number of examination centres, and the obvious impossibility of sending examiners simultaneously all over the country, led to the elaboration of the system of local committees to supervise examinations worked from a single centre. The successful establishment of this system was much facilitated by the Society's "Union of Institutions" established a few years previously, in 1852, and it was through the Union that the examinations were then and have since been carried on. The idea was due to the late Mr. Harry Chester, who was the founder of the Society's Examination system, as of the Union itself.

To the Examinations in 1858, 58 institutions sent up 288 candidates; in the following year there were 480; in 1860, 586. The numbers increased steadily till 1865, when there were 1,899; the next year showed a slight diminution, and then there was a further increase, till the highest number was reached in 1869. In that year there were 2,160, the greatest number who have ever presented themselves. These candidates were sent up by 139 local boards.

The establishment of Elementary Drawing Examinations by the Department of Science and Art was about contemporaneous with that of the Society's Examinations. The Science Examinations began later, in 1861. It is instructive to compare the growth of these with the progress made by those of the Society. In 1877, the Department examined 22,523 Art students, at 144 centres, and 35,342 Science students, at 1,348 centres.

When the Society's Examinations were established, they fairly covered the range of a liberal modern education. They included at first 26 subjects, afterwards as many as 36, amongst which were included Mathematics, Pure and Applied Chemistry, Electricity, &c.; Botany, Agriculture, Political Economy, Logic, Latin, Modern Languages, English, Drawing, Music, &c.

They were in two divisions, elementary or preliminary, and final. The whole scheme was complete, and had been most carefully thought out. The Society had the ground to itself, and it may fairly be said that it filled it satisfactorily. But as the work of the Science and Art Department grew, it was found that the Society's Examinations were in many respects competing with those of the Department. The same candidates were being examined in the same subjects, and there was an evident waste of power. In 1870 this led to the abandonment of 17 out of the 36 subjects then included. In 1871, the Council passed a resolution to discontinue the Examinations, in view of the establishment of the Technological Examinations; but, on the application of some of the more important of the Institutions in Union, they rescinded this resolution, and determined to continue the Examinations for a further period. This was done, on the same system as before, till 1876, when the programme was revised, and the plan on which certificates were granted was somewhat modified. Previously, certificates had been granted for single subjects, but in that year a "Commercial Certifi-

cate" was established in addition, to take which it was necessary to pass in, at least, three of the subjects retained as forming part of a sound commercial education. It is rather remarkable that very few of these certificates have been taken, the number being, in 1876, 68, with 974 candidates; in 1877, 63, with 1,185 candidates; in 1878, 70, with 1,330 candidate; in 1879, 77, with 1,494 candidates.

It may be worth mention that the only subjects which ever attracted large numbers of candidates, were English, French, Arithmetic, Book-keeping, and Music. It also appears, from an examination of the lists for some years back, that the same candidates come up for examination in the same subjects over and over again, often without showing any real progress.

Looking at these facts, the Committee feel that the time has now come when the Society should cease to compete with other educational agencies more influential in the work of examination. With the Education Department examining millions of children in elementary schools, and thousands of young persons in night classes; with the Universities holding their local examinations throughout the country for young persons of a higher class; with the Science and Art Department examining students in every branch of science and of art; with the new City Institute developing yet further the Technological Examinations just handed over to them by the Society; with other agencies, such as the College of Preceptors, doing kindred work, the Society of Arts may well retire from the field, having in all these various directions acted as the pioneer. It held science examinations before the Science Department, examinations in literature before the Universities went a-field to meet the classes who could not go to Oxford or to Cambridge. It has seen the system it established develope, with the aid of Government funds, as it could never have grown without such help, and the time has now arrived when it may cease to compete with the agencies it has done so much to foster.

The consideration of the whole subject, therefore, leads the Committee to recommend that after 1880 the Examinations of the Society should be discontinued, except the examination in Music, Domestic Economy, and Political Economy.

They also recommend that no changes should be made in the Programme of Examinations for the coming year (1880), except that no prizes should be given in any subjects other than the three above mentioned.

They further recommend that after the year 1880 the "Prince Consort's Prize" should be given, with the sanction of H.M. the Queen, to the best candidate in the examination in Music, on conditions to be hereafter determined.

CANTOR LECTURES.

DWELLING-HOUSES: THEIR SANITARY CONSTRUCTION AND ARRANGEMENTS.

By Prof. W. H. Corfield, M.A. M.D. (Oxon).

Lecture III.—Delivered March 3, 1879.

Water Supply.

For the purpose of these lectures we must assume that it is necessary to have a sufficient supply of water that is fit to drink for all uses. The obvious characters of a good drinking water are that it is clear, transparent and colourless, without taste (that is to say, neither salt nor sweet), and without smell, that it has no suspended particles in it, and produces no deposit on standing, and that it is aerated; but a water may possess all these characteristics and yet be unfit to drink, by reason of dissolved matters which cannot be detected except by chemical analysis, but the existence of which may often be suspected from a knowledge of the history of the water. Waters are commonly divided into hard waters and soft waters. Hard waters are those which contain a considerable quantity of mineral salts, especially salts of lime, in solution; soft waters those which contain much smaller quantities of these substances. Very hard waters are unfit for domestic purposes. A deposit of mineral matters takes place in the supply pipes, &c., and they get blocked up. Such very hard waters, too, are not desirable either for drinking or for domestic purposes generally. Moderately hard waters appear to be as wholesome as soft waters for drinking purposes. The Registrar-General has shown that the death-rate, in towns supplied with moderately hard water, does not differ sensibly from that of a series of towns supplied with soft water, but in other respects similar in their sanitary arrangements. Nevertheless, animals in their natural state prefer soft water to hard, and those who have the care of horses always give them soft water to drink if possible. An undoubted disadvantage that attends the use of hard water for domestic purposes consists in the enormous waste of soap that it entails. In order to wash with soap, it is necessary to produce lather. Now, the mineral salts in hard water decompose the soap, and form insoluble compounds, so that solution of the soap in water which will form a lather, does not take place until the lime, &c., in the water has been deposited as insoluble lime-soap, &c. Thus the more salts of lime and other mineral matters are present in the water, the more soap is wasted before the formation of a lather. This can be easily illustrated by a simple experiment. If we take a sample of distilled water, which contains no mineral matters in solution, and add a certain measure of an alcoholic solution of soap to it—when we shake the bottle in which it is, a lather is immediately produced and remains for some time; but when we take the same quantity of another sample of water, and add the soap solution to it, we find that it requires, in this instance, about 20 times as much of the solution to form a lather. (Experiment shown.) Soft water then, on the whole, must be preferred to hard for domestic purposes, and when the water is very hard it ought to be softened before being distributed. This may be done by Clark's process, which consists in adding milk of lime to the water as long as a precipitate is formed. The *rationale* of this is that most of the hard waters contain considerable quantities of carbonate of lime, which is held in solution in the water by the means of free carbonic acid. The lime added as milk of lime combines with the free carbonic acid, forming more carbonate of lime, which, together with the carbonate previously in solution, is deposited, being almost entirely insoluble in water. As it is deposited, it carries

down with it any suspended matters that may be in the water, and so leaves the water clearer and purer. A practical difficulty in the carrying out of this process, arising from the length of time required for the precipitate to subside, has been overcome by a process of filtration devised by Mr. Porter, and known as the "Porter-Clark process." Water after being distributed may be softened to a considerable extent on a small scale by boiling, when the carbonic acid gas is thrown off, and the carbonate of lime deposited. It is this which causes the incrustation of boilers. The boiling also helps to purify the water in other ways, and it is a very good plan to use boiled water, either when the water is very hard, or when there is any suspicion of impurity, both for drinking and for domestic purposes generally. It may be aerated by allowing it to fall from a height from one vessel into another. The average quantity of water required in a community is generally put down at from 30 to 35 gallons per head daily. Of these, from 20 to 25 are required for household purposes (including waste), where baths and water-closets have to be supplied, and ten or more are necessary for washing the streets, for flushing the sewers, and for trade purposes.

The important sources of water are:—(1.) Rain collected directly. This is of course very soft water, and in country places very pure. In towns it is rendered impure by the substances that it washes out of the air, and must be filtered before it is used, but it is everywhere an important and valuable source of soft water which is far too much neglected. It ought to be collected and used for domestic purposes, and wherever there is any suspicion as to the quality of the water supplied from other sources, rain-water should (especially in the country) be used for drinking. It may be filtered through sand, gravel, or charcoal by means of very simple contrivances.

(2.) Water is often obtained from shallow wells dug in the soil, down to a little below the level of the subsoil water. These, of course, drain the soil around for a greater or less distance, and the water in them frequently becomes contaminated by foul matters from leaky sewers, cesspools, &c., especially in pervious soils. Persons should therefore always be suspicious of the quality of water derived from shallow wells, for frequently, even when bright and sparkling, it is highly contaminated.

(3.) Springs and small streams are often used to provide supplies of water, and very pure water is obtained in this way, although it is sometimes rather hard. It is either conveyed directly to the town by means of aqueducts or pipes, after the Roman plan, or collected from a gathering ground into large impounding reservoirs, and thence taken in pipes to the place to be supplied.

(4.) The water of large rivers is now frequently used as a source of supply. It is received in settling basins or reservoirs, where a deposit takes place, then filtered through beds of sand and gravel, and afterwards distributed. Most of the river water is contaminated in various ways during its passage through towns; and, without entering further into the subject here, I would merely say that it is better to obtain water that has not been contaminated, than to take water which we know has been contaminated, and then try to purify it.

(5.) Water is sometimes obtained from pervious water-bearing strata, at a considerable depth below the surface of the ground, by boring into them through the impervious strata which lie over them, and through which the water cannot penetrate. Wells with such borings from the bottom of them are known as artesian wells, from having been first generally used in the French province of Artois. The water contained in such water-bearing strata is supplied by the rain which falls on the outcrop of these strata, often at a considerable distance, and frequently, as in London and Paris, on the hills around. This water percolates through the pervious rocks, and so gets beneath the impervious strata which lie over them after they have disappeared beneath the surface, and, being retained there under pressure, rises through borings made into the rock in which it is, through the impervious strata lying over it. This water, then, is generally, as may be expected, very pure, although it is frequently, especially if derived from the chalk, as that supplied by the Kent Company to London, very hard. Occasionally, as in some wells bored into the New Red Sandstone, it contains too much common salt to be fit for domestic purposes, which will not be wondered at when we consider that the largest deposits of salt we have, from which enormous quantities are obtained, are in the New Red Sandstone formation.

However the water is obtained, it is distributed to the houses in one of two ways, either by intermittent or by constant service. With the system of intermittent service, the water is turned on into the houses once or twice in the 24 hours for a short period each time. It is, therefore, necessary to have cisterns, butts, tanks, or receptacles of some kind to keep the water in during the intervals. In these, deposit occurs of the suspended matters contained in the water, and dust accumulates, especially if they are not covered, or if the covers are broken, and so the water is rendered impure. They also usually have a waste or overflow pipe, which is frequently connected with the sewers or with some part of the water-closet apparatus, and by means of which foul air finds its way into the cistern and contaminates the water. During the intervals, too, when the mains are not charged with water, foul water and foul air find their way from the soil around through leaky joints, and contaminate the water when it is next turned on, so that it frequently happens that the first water that comes into the cistern when it is turned on is quite unfit to drink. There is an enormous amount of loss with this system, which might, however, in great part be prevented. The last disadvantage of the intermittent supply lies in the fact that some delay is frequently experienced in obtaining water for extinguishing fires.

With the system of contant service, on the other hand, the pipes are always full, and so it is not necessary to have cisterns, or receptacles of any kind for the storage of drinking water, although this is frequently done. Receptacles are, however, necessary for the supply of water to closets. The pipes being always full of water under pressure, are far more likely to leak out into the soil than to be contaminated with foul matters from the soil. Still, it is not advisable on any account that water-pipes should be carried near to sewers or other

sources of contamination. The water is fresher, and purer, and cooler in summer when supplied on the constant service system. The pipes are full in case of fire, and the inspection of pipes, taps, and other fittings is, as a matter of fact, carried on very much better, and less waste of water takes place under this system (although the pipes are always charged) than under the other system. It is obvious that, unless there were very strict supervision, a great waste of water would necessarily accompany the use of the constant system. For this reason also, the water companies that have adopted that system will not allow waste pipes from cisterns to be connected with the sewers, or closet apparatus, but insist on their discharging freely in the open air; and usually in some place where any waste water running out of them would produce annoyance, so that it would be speedily noticed, and the cause of the waste remedied. It is very important, however, where this system is adopted, that there should be double reservoirs or tanks, in order that one may be used while the other is being cleared out, for if, as has been the case at some places, and notably at Croydon, the water be supplied by the intermittent system of service for a few days, defects which have produced no inconvenient results while the constant system of supply was practised (such as the connections of water-closet hoppers directly with the main water-pipes), the possibility of the existence of leaky joints in the mains, through which foul matters may enter from the soil, &c., may produce the gravest results by spreading enteric fever throughout the community; and here I may mention that it is, of course, extremely improper and very dangerous to convert a cistern which is used to supply drinking-water, or a water-supply pipe, directly with the hopper of a water-closet. The system of constant service is coming gradually into more general use, and it is very probable that water-meters will be much more generally used than they are at present. A simple apparatus of this kind is Abrbecker's water-meter, in which the water is made to pass through oblique apertures in a fixed plate into oblique or spiral passages in a cylinder which is capable of rotating, and the axle of which turns the index of a dial. The pipes, by means of which the supply of water is conveyed into the houses from the mains, are usually made of lead; this material being preferred on account of its durability, and the facility with which it can be bent in various directions. A disadvantage of it is, that certain waters attack and dissolve lead, and are thereby rendered more or less poisonous. Those, however, are chiefly pure and soft waters. Waters containing mineral salts in solution, such as those generally supplied for drinking purposes, scarcely attack lead at all; and moreover, with waters which do attack lead, the surface of the metal becomes covered with an insoluble coating of oxide and carbonate, which protects it from further attack. Pipes made of lead lined with a thin layer of tin are sometimes used, but when the tin becomes damaged in any way, a galvanic action is set up, and the lead is dissolved quicker than ever. Varnishes of various kinds have been proposed for coating the interior of water-mains and pipes. Most of them are very objectionable—one of them positively containing arsenic. Wrought iron pipes with screw joints are sometimes used for water pipes. They are certainly cheaper than lead, and it is said that they will last longer. Bends are made of almost every possible shape just as in gas pipes. In some rare instances lead pipes are attacked from the outside by water containing carbonic acid in the soil, as shown in a sample of a lead pipe which had been laid in chalk, and which was contributed to the Parkes Museum by Mr. Bostel, of Brighton.

The receptacles used for storing drinking water are made of various materials. Leaden cisterns have long been frequently used on account of their durability. They are open to the same objections as lead pipes, although from the fact that no mischief has been found to result from the use of lead pipes and cisterns at Glasgow, since it has been supplied with Loch Katrine water, which is exceedingly soft, it appears probable that the ill-effects from the use of lead in this way have been exaggerated. Galvanised iron cisterns are fast taking the place of leaden ones. They are very durable, and of course far cheaper then lead. Stone or even brickwork lined with cement are sometimes used at or below the ground level for the storage of water, and are open to no objections so far as the material is concerned. Stoneware cisterns are now made, and are admirably suited for cottages, for use in basement floors, &c. Slate cisterns are not unfrequently used for upper stories, as well as ground floors. Of course, slate in itself is an excellent material for such a purpose, but slate cisterns, unfortunately, are very apt to leak after a time, and the joints are then filled in with red lead from the inside of the cistern—a practice which is, of course, very objectionable. The use of wooden receptacles, such as tubs, butts, &c., ought to be discouraged, if only because they are difficult to be kept cleansed. A self-cleansing tank is sold by the Sanitary Engineering and Ventilating Company. The bottom, instead of being flat, is made to slope from all sides towards the centre, where the waste pipe is fixed. On lifting up, by means of a lever, that part of the waste pipe which stands up in the cistern, and which is fitted accurately into the commencement of the pipe at the bottom of the cistern, so as to make a water-tight joint, the water runs out of the cistern, and on account of the sloping bottom washes all the sediment away with it. The water is generally supplied to the cistern from the pipes through a tap known as the "ball-valve." To it is attached, by means of a metal bar, a hollow copper sphere or ball, which floats on the water as it rises in the cistern, and when it has risen to a certain height turns off the tap. It is because these taps are liable to get out of order, that a waste or overflow pipe is necessary. This waste or overflow pipe should, in all cases, without any exception, discharge freely, as over an area, &c., so that you can see the water coming out at it. All receptacles of water should be well covered, in order that dust may be kept out of them. Nevertheless, ventilation space between the water and the cover, by means of holes provided with a grating, at the sides, is advisable.

Of course, for drinking water, we ought to choose a source of supply that is unpolluted. As Mr. Simon has said, "It ought to be an absolute

condition for a public water supply that it should be uncontaminable by drainage." We ought not, then, to take confessedly impure waters and try to purify them, so as to make them fit to drink. On the other hand, it is obviously unnecessary to use very pure water, except where there is a superabundance of it, for washing the streets, flushing the sewers, and supplying the water-closets, and so it may be advisable in some places to have a double supply of water, one of pure water for drinking and cooking, derived, for instance, from artesian wells, and the other of an inferior character for other uses. This has been lately proposed for London, and whatever may be said against it on the score of expense, I think most people will agree that it will be very desirable to have water to drink which has not been first polluted with sewage and then filtered. The advantage of this plan too, was perfectly well recognised by the ancient Romans. Frontinus tells us that it pleased the Emperor (as he puts it) to order that the water supplied by certain aqueducts should be furnished to the people for drinking purposes, while that supplied by some others, from its being occasionally turbid and of inferior quality, was to be used for "viler purposes."

As, however, we do not, as a matter of fact, in the majority of instances, imitate the ancient Romans, either in this particular or in bringing pure water from a distance to supply the towns, but use the nearest water that we can get, whether good, indifferent, or bad, it is of course necessary for us to do all that we can to purify it before use. This is done on a large scale by filtration through layers of sand and gravel, after the coarser suspended matters have been allowed to deposit themselves in a settling tank. I shall not describe this method of filtration in detail here, as it is a little beside the scope of these lectures, but, as the principle on which it acts is the same as that upon which the success of most forms of domestic filter depend, I may say a few words about it once for all. The experiments made by Dr. Frankland for the Rivers Pollution Commissioners showed that when foul water was passed through layers of porous soil, or sand and gravel, the amount of organic matter in it was reduced, if two conditions were fulfilled; these are, that the filtration be downwards and intermittent. It was found that if the filtration were upwards or continuous no such purification occurred after a time. The explanation of these facts is simple. The filtering material acts in two ways. It separates mechanically suspended matters in the water that are too large to pass through the pores of the filtering material, and it also acts chemically by means of the oxygen of the air in its pores, when, as the water flows downwards through the filtering material, it percolates through by means of a number of very small streams, and so is brought into the most immediate contact with the oxygen of the air in the filtering material. Thus, the organic matter and ammonia dissolved in the water are oxidised with the production of nitrates and carbonates, and it is certain that by this means a considerable quantity of organic matter is reduced to a harmless condition. Domestic filters, clearly, ought not to be required. The water ought to be delivered sufficiently pure to drink.

And here I would remark that the average quality of a drinking water supplied to a place is not the matter of most importance, and, indeed, is rather a fallacious guide. What we want to know is the quality of the worst sample that the public are likely to be supplied with at any time. But it is not only because the water supplied varies in purity, in most instances, sometimes considerably, that domestic filters are useful, but because, as I have before remarked, especially where the intermittent system of supply is in vogue, the water, even if delivered pure, is rendered impure in the houses themselves by being stored in filthy receptacles. The majority of the filters in domestic use rely upon the principle of downward filtration. In a few, the water is passed upwards through a filtering material. The chief materials used are animal charcoal — vegetable charcoal is not a good material for filtering purposes—silicated carbon, carbide of iron, spongy iron and sand. When animal charcoal is used, it must, be specially prepared and well-burned. If any of the animal matter be left in it, it becomes, as has been shown by the Rivers Pollution Commissioners, a breeding place for myriads of small worms which pass into the water. With the other materials mentioned, there is, of course, no risk of this, as they are made of burnt shale, or taken from the interior of blast furnaces. Some filters are placed inside the cisterns, so that all the water that is drawn off has to pass through them. These are placed on the main water pipes themselves, or in the taps. One of the former kind, known as "the self-cleansing filter," in which the suspended particles in the water are prevented from getting at the filtering material by a ring of compact silicated carbon, and the water itself is made to wash the outside of the block of filtering material through which it has to pass. My experience goes to prove that filters that are always under water, cease to purify the water after a time, unless means are taken for aerating them, and in many instances I have known water to be rendered more impure by its passage through a filter which had been used in this way for a considerable time. Of forms of domestic filter, the glass decanter with a solid carbon or silicated carbon block has the great advantage that every part of it can be seen, so that it can be kept scrupulously clean. These filters will go on working perfectly well for an almost unlimited time, scarcely anything being necessary beyond cleansing the surface of the block once now and then with a hard brush. It is a very good plan to have a kind of double filtration. Sometimes the water is made to pass through a piece of sponge before falling on to the filtering material with the view of arresting the coarser suspended matters. It is far preferable, however, to use the carbon block for this purpose. In Prof. Bischoff's spongy iron filter the filtering material is always under water, and the action which goes on in it is certainly quite different to that which I have explained, and is as yet little understood. The River Pollution Commissioners have expressed the highest opinions of this substance as a filtering material. On account of the fact that the water dissolves a little of the iron on its passage through the spongy iron, it is made to pass through a layer of prepared sand afterwards, with the view of removing this, and then, in order

to aerate it, it is delivered through a very small hole in a fine stream into the pure water receiver. It will thus be seen that it is rather more complicated than some of the other forms of domestic filter. The slight trace of iron that remains in the water can hardly be considered a disadvantage, at any rate in large towns.

Lastly, I must notice the filter made by the General Sanitary Engineering and Ventilating Company. In this, by an ingenious contrivance, the air passes to and from the filtered water chamber through the filtering material itself, and not by means of a small channel in the china or earthenware vessel holding the filtering material, as is the case in other filters. The water first passes through a silicated carbon block, and then falls in the form of a shower on to the surface of a layer of some loose silicated carbon supported upon a perforated plate which is not flat, but has elevations here and there on its surface. The result is, that not only when the water is drawn off by the tap does air pass through the filtering material into the filtered water-chamber, but also as the water flows through into this lower chamber it forces the air out through the filtering material itself, which it is enabled to do by means of irregularities on the surface of the plate upon which the filtering material rests. If this plate were quite flat as it was heretofore made, and if there were no air-pipe from the lower chamber, a balance would be established, and both water and air would cease to pass through the filtering material.

When rain-water is used for drinking, and even for other domestic purposes, it is advisable to filter it, and the best form of filter for this purpose is one devised by Professor Rolleston, of Oxford. The tank to receive the rain-water has two compartments, divided from one another by a vertical partition, and each having a horizontal layer of filtering material, as charcoal, placed on a perforated support half-way down the tank. The rain-water pipe from the roof is brought down through this filter-bed nearly to the bottom of one of the compartments. The rain-water then has to pass upwards through the filtering material in this compartment over the partition into the second compartment, and downwards through the filtering material there, into the lower part of that compartment, where there is a tap from which it may be drawn off. An overflow pipe is, of course, provided, so that the water cannot rise above a certain level.

In conclusion, I need only say that the number of instances in which epidemics of typhoid fever, cholera, and some other diseases, have been traced to the use of impure water, or of milk contaminated with foul water, must make it evident to everyone that it is of the greatest possible importance that we should have uncontaminated sources of water.

NATIONAL WATER SUPPLY.

SUGGESTIONS FOR DIVIDING ENGLAND AND WALES INTO WATERSHED DISTRICTS.

Essay by Samuel B. Goslin.

"The princes digged the wells by the direction of the lawgiver."

The Subject.

It is hardly necessary to say that, in whatever light the problem is viewed, it is seen to be as vast in its magnitude as it is in its importance to the well-being of every individual in particular, or to the nation at large, not only for the present time but for generations to come. Recent legislation having to an extent laid out the ground for operations to be commenced, it remains—

(1.) To take an account of the requirements and conditions.

(2.) To consider the best and most available resources and materials for the work.

(3.) To divide the country, or to delineate the plans for operation.

(4.) To have the works carried out.

(5.) To provide the money for payment.

Withal taking the experiences of the past, and the collected evidence already given, as the guide to the final determination upon every proposal or point connected with the subject.

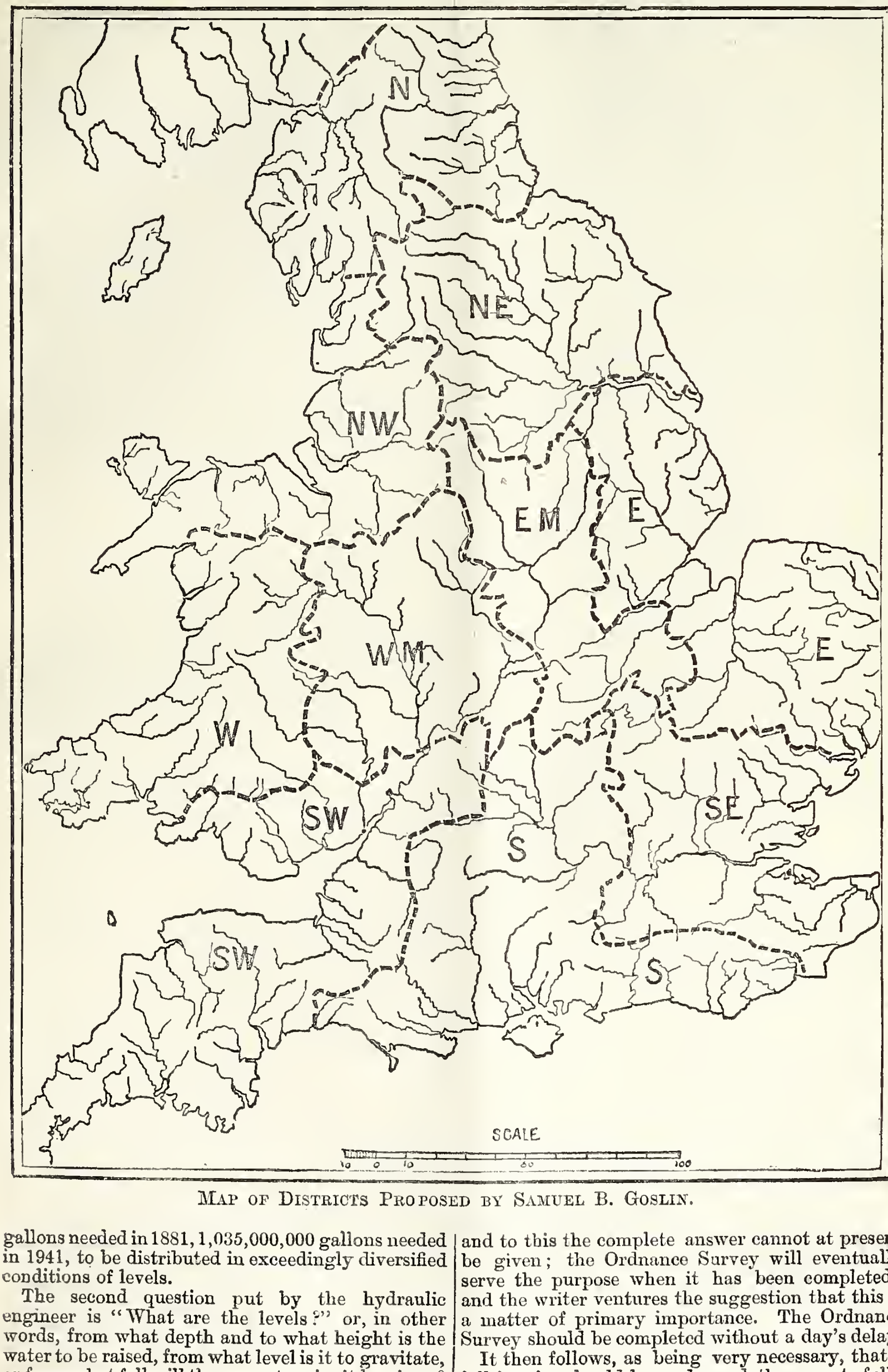
Proposals.—Requirements, &c.

The requirements or conditions of a water supply is always the first question put by the hydraulic engineer, whenever consulted, both as to the present and future periods, whether it be for city, town, village, mansion, farm, or factory; if it be for the nation, the same particulars or statistics are absolutely necessary. The particulars have been, to a very large extent, already compiled and supplied, but are not so complete in all their details as it is desirable that they should be.

It is to be seen that there are 25,349 various and separate places in England and Wales to be supplied with potable or "pure and wholesome" water in varied quantities, these places being comprised in 2,061 unions, 4,158 townships, 9,694 parishes, 470 hamlets, 102 chapelries, 151 tythings, with some few municipal boroughs, villages, liberties and precincts, covering an area of 53,320 square miles, with a population, in 1861, of 20,066,224; in 1871, 22,712,266; now about 25,000,000, with some 14,000,000 dwelling in towns and urban districts, and 11,000,000 dwelling in rural districts, villages, and small towns.

The population in the metropolis and urban districts is increasing rapidly, and that of the rural districts slowly, as was shown, in 1871, to be in the proportion of 1·73 for the urban against 0·71 in the rural districts. The population of necessity existing in two distinct classes, viz., (1) those closely packed in large towns and cities, easily served; (2) those dwelling in country parishes, villages, mansions, farms, &c., for the most part widely separated—as for instance (1) St. Pancras Union, Middlesex (one parish) with a population of 221,465, in 2,672 acres; (2) Staines Union, of 13 parishes, 20,199, in 24,332 acres; Aysgarth, Yorks, Union, of 12 parishes, 5,473, in 81,012 acres.

The present requirements, so far as quantity is concerned, may be easily computed, and the increase upon that quantity, which will be necessary in 60 or 70 years hence, may be gathered from the census tables, or the averages may be fairly set down as $12\frac{1}{2}$ per cent. increase for every period of 10 years, so that as, in round numbers, the population to be supplied in 1871 was 22,700,000, in 1881 will be 24,500,000, in 1891 will be 28,700,000, in 1901 will be 32,300,000, in 1911 will be 36,300,000, in 1921 will be 30,900,000, in 1931 will be 46,000,000, in 1941 will be 51,700,000, and taking 20 gallons per diem per head, shows a quantity of 454,000,000 gallons needed in 1871, 511,000,000



Map of Districts Proposed by Samuel B. Goslin.

gallons needed in 1881, 1,035,000,000 gallons needed in 1941, to be distributed in exceedingly diversified conditions of levels.

The second question put by the hydraulic engineer is "What are the levels?" or, in other words, from what depth and to what height is the water to be raised, from what level is it to gravitate, or from what fall will the power to raise it be given? and to this the complete answer cannot at present be given; the Ordnance Survey will eventually serve the purpose when it has been completed; and the writer ventures the suggestion that this is a matter of primary importance. The Ordnance Survey should be completed without a day's delay.

It then follows, as being very necessary, that a full inquiry should be made, and the reports fully

recorded of all the existing conditions of every place in the country, the depths and water levels in all the wells, the size and analysis of all the streams, &c.; but this can only be done by an appointed Board or Commission, acting in various departments, if it is to be accomplished in a reasonable time. It has been shown in part by the Rivers Pollution Commissioners' reports, and by the reports of other inquiries, as well as being fully realised after a few visits in various parts of the country, that the conditions are as diverse as it is possible to find them.

In many cases, in rural districts, there is a supply of water at the feet of the people, only needing some simple machinery to lift it; in other cases, difficult to be found anywhere near, either in wells or streams, of a pure and wholesome character. In some cases, the people are hindered, by incompetent water companies or selfish landowners, from obtaining the available supply; in others, the people are supplied by exacting and wealthy corporations. In some cases, the people using and drinking sewage impurities from ponds, tanks, and streams, as the only available source and supply; in others, the purest water being supplied from deep-seated springs, by local authorities, borough corporations, and smaller public companies.

It cannot be worth while to upset an existing arrangement, if it be found to be adequate and sufficient for a prospective increase of population in its mechanical arrangements, even if it is considered to be advisable to have it placed more directly under Government supervision, which every water supply should be, as a decidedly "national question."

The best and the most available resources have received considerable attention, as the rainfall, the rivers, the lakes, the wells, the streams, but not sufficient for this question, as the record will show at a glance, taking those of the rainfall from the 2,000 stations in existence. They do not by any means give accurate and trustworthy data of the 25,349 places in the country. It is not sufficient to map out and mark off certain spaces of average without stations of record, as in the east part of the Tendring Hundred district in Essex, where it is placed and averaged at the same rate as between Romford and Colchester in the same county. It is proverbial that the former has but little rain compared with the latter, as when at the latter a comparatively continuous rainfall was experienced for six weeks, two small showers were the portion of the former.

It is seen that the rivers and streams are for the most part polluted; that the wells contain, in some cases, brackish water; but in most cases where deep or artesian, there is a bountiful supply of pure water, irrespective of particular district rainfall, much as it is in other countries, as India, Africa, New Zealand, &c. The lakes offer an abundant water supply, fed by rains which have been measured to some extent, and, mists which, although of more frequent occurrence, few records, and little notice have been taken, nevertheless they form an important factor in the question of water supply.

The velocity or pressure of the wind, another factor of great importance in connection with water supply in urban and rural districts, has never been recorded throughout the country.

The geological statistics and records serve well as a basis to start upon in connection with a hydro-geological survey; a work absolutely essential for the determination of the question of "National Water Supply," the geological records serving as an indication of the qualities of the waters in some particulars, but often insufficient, as in the chalk underlying clay pure water may be found at Thorpe-le-Soken and at Walton-le-Soken, four miles only distant from Thorpe, the water from the same strata is brackish, and useless for the purpose desired. So is it in many other cases.

The hydraulic engineer naturally inquires as to the available resources before he can draw the lines of his plan, or give his decision or advice for a water supply. And, considering that, in connection with the question of the National Water Supply, the magnitude and variety of the requirements, the diversity of the conditions, the imperfect knowledge of the available local resources, the incomplete data of the geometrical, geological, and meteorological aspects of the country (the most complete information being necessary), these must influence the divisions of the country which may be desirable at the present time.

Everything points to the fact that, wherever the divisions are made, or the lines drawn, they can now only represent the parts of a scheme, which may ultimately be improved in the final arrangement. This is clear, and can be decided at once—that no one scheme or arrangement will be found to be suited to every place, or group of places.

To effect a satisfactory result, the country should be divided into parts, or departments, and subdivided into districts, as they are termed in France, each department being under the control and study of various officers of a "National Hydraulic Board," or "Board of Public Works," whose duty it should be at once to collect the necessary data of every district in their department, as per Form A, their departments, or divisions, being those of the rivers, as in France, or, for the immediate purpose, as per Map and Table A, or Key B, which divisions include a series of complete counties.

There are many advantages arising out of this plan of division, inasmuch as that the counties are already divided into urban and rural districts, with their respective authorities, all the statistics gathered of population, acreage, rateable value, collectors, and places of meeting, having every facility for the collection of funds for the work required, and the supervision of the works when determined upon. It is the fact that, in most, if not in every case where there is no good supply at the present time, the evil has continued, more from the want of a decision as to what should be done, than from inability to find the money or the workmen to carry out the work, there being self-interests, diversities of opinion, and the fear of not doing the best, or spending money of the ratepayers badly, which have hindered progress in public works in urban and rural districts.

It is necessary, at the present juncture, that a decision of the department of the National Hydraulic Board should be given as to what is to be done, and the law made that it must be done or carried out.

It would be an easy matter for the engineering branch of the National Hydraulic Board to decide the question what is to be done in each district, in a group of districts, or in the department, when the statistics are taken as enumerated,

whether the supply should be from lakes, wells, or streams, or whether the distribution should be effected by gravitation, by water power, by wind power, or by steam power; each having their special advantages under certain conditions.

For the payment of the outlay and maintenance, the easiest and best plan is to take the existing Unions or districts in departments, as shown where the Poor-law Act is in force and rural sanitary authorities exist; for the assessment several plans may be suggested.

1. Let the cost be charged upon the land, as the landowners must reap the benefit of improved property more suited for human habitation.

2. Let every ratepayer, upon the usual assessment of the poor's rate, pay his part of a consolidated national water supply rate, so that the wealthy help the poor, the strong help the weak.

3. Let every male be taxed upon a return of income or wage, the return being collected at the time of the census, so that the working man or mechanic may pay his proportions as well as the poor clerk, the landowner, or nobleman. For all this there must of necessity be an Act of the lawgivers; they must strike the rocks of hard places, ideas, and circumstances.

1. To appoint the permanent National Hydraulic Board to deal with the National Water Supply and sewage disposal.

2. To sanction or appoint the lines or boundaries of the departments and districts.

3. To give power to that Board to consider and decide what is best, and to be done in each and all cases.

4. To appoint the means, so that the decisions shall be put into operation by rural or sanitary authorities, or the Public Works Department.

5. To appoint the officers for the permanent inspection and maintenance of the National Works.*

6. To decide upon the place of assessing for the funds required.

7. To decide upon the means of collection, that all may be paid.

TABLE A.

National Water Supply.

Departments.	Counties included.	Acreage.	Population.	Rateable Value.	Rainfall Average.
North........	Northumberland	1,290,312	386,646	£ 172,578	25 to 70 inches.
	Cumberland	970,161	220,253	97,295	
	Westmoreland	500,906	65,010	26,168	
	Durham	647,592	685,089	283,741	
		3,408,971	1,356,998	£579,782	
North East ..	Yorkshire:—E. Riding.	750,828	268,466	153,174	25 to 30 inches.
	N. Riding.	1,361,664	293,278	135,478	
	W. Riding.	1,790,359	1,874,611	761,374	
		3,902,851	2,436,355	£1,050,026	
North West..	Lancashire............	1,207,926	2,819,495	1,410,698	40 to 50 inches.
	Cheshire..............	705,493	561,201	260,459	30 to 50 inches.
	Denbighshire..........	392,005	105,102	Wales not divided	25 to 75 inches.
	Carnarvonshire...... .	369,482	106,121		
	Anglesey	193,511	51,040		
	Flintshire	169,662	76,312		
		3,038,079	3,719,271		
East	Lincolnshire	1,767,962	436,599	237,591	under 25 inches.
	Rutland	94,889	22,073	14,415	
	Norfolk................	1,356,173	438,658	269,351	
	Suffolk	949,825	348,869	199,425	
		4,168,849	1,246,197	£720,782	

* For staff and departments of the staff of the National Hydraulic Board see D. form.

Departments.	Counties included.	Acreage.	Population.	Rateable value.	Rainfall Average.
East Midland.	Derbyshire	656,243	379,394	134,824	25 to 40 inches.
	Nottinghamshire	526,176	319,758	191,303	
	Leicestershire	511,719	269,311	179,634	
	Northamptonshire	629,912	243,891	192,028	
	Huntingdonshire	229,515	63,708	44,866	
	Cambridgeshire	524,926	186,906	138,113	
		3,678,491	1,462,968	£880,318	
West	Merionethshire	385,291	46,598	Wales not divided	40 to 75 inches.
	Montgomeryshire	485,351	67,263		
	Cardiganshire	443,387	73,441		
	Radnorshire	276,552	25,430		
	Pembrokeshire	393,682	91,998		
	Carnarthenshire	606,172	115,710		
	Brecknockshire	460,158	59,901		
		3,050,593	580,341		
West Midland	Staffordshire	732,434	858,326	331,466	25 to 30 inches.
	Shropshire	841,167	248,111	137,630	
	Warwickshire	566,458	634,189	308,577	
	Worcestershire	472,453	338,837	174,331	
	Herefordshire	532,898	125,370	116,425	
		3,145,410	2,204,833	£1,068,429	
South East .. * Part 1	Bedfordshire	295,509	146,257	111,413	25 to 30 inches.
	Hertfordshire	319,141	192,226	140,255	
	Essex	1,055,133	466,436	318,887	
		1,741,783	804,919	..	
* Part 2	Middlesex	181,317	2,539,265	2,030,627	
	Surrey	483,178	1,091,365	723,477	
	Kent	1,004,984	848,294	610,560	
		1,669,479	4,478,924	£3,935,221	
South .. * Part 1	Oxford	470,095	177,975	130,789	25 to 40 inches.
	Buckinghamshire	467,009	175,879	40,697	
	Berkshire	450,132	196,475	167,188	
	Wiltshire	859,303	257,177	196,484	
* Part 2	Hampshire	1,032,105	544,684	320,692	
	Dorset	627,265	195,357	135,278	
	Sussex	934,006	417,456	298,943	
		4,839,915	1,964,603	£1,340,271	
South West ..	Glamorganshire	547,070	397,859	Wales not divided.	25 to 75 inches.
	Monmouthshire	368,399	195,448	116,008	
	Gloucestershire	804,997	534,640	293,501	
	Somersetshire	1,049,815	463,483	330,017	
	Devonshire	1,655,161	601,374	342,222	
	Cornwall	869,878	362,343	169,764	
		5,295,300	2,555,147		

Geology.—(See Table D.)—Mr. Best says:—"The geological survey of England and Wales is not in a complete state, and the maps generally do no more than show the strata directly under the top soil. The description of the geology of the counties of England and Wales has never yet been compiled. Mr. W. J. Harrison, of the Town Museum, Leicester, has the work in hand for Messrs. Kelly; he has finished, and that of 25 counties has been published. W. J. H. is "in hopes" of finishing his work this year, which will be exceedingly useful. It is highly necessary not only to take the geology of every county, but of every place, with the water-bearing strata, as has been said by Mr. Best, 'because in chalk you get water in one place, it does not follow that you will in nother.'"

Note.—The average acreage of departments is from 3 000,000 to 5,000,000.

* It may be advisable to divide S.E. and S. departments into two parts; total acreage or S.E., 3,411,262; population, 5,283,843.

PLACE. TABLE B. COUNTY.

Department.	District.	Population.	Ratio of Increase.	Acreage.	Dwellings—Number of.	Present Water Supply, if any—Description of, with Analysis.	Rainfall and Mist—Average of.	Wells existing—Description of, with Depths, and Strata passed.	Lakes and Streams—Description of.	Levels—Ordnance Datum.	Geological Formation of Water-bearing Strata.	Wind Pressure or Velocity.	Waterfalls—Description of, Height, Quantity.	Adjoining or Next District—Name and Distance of.	General Remarks.
Decisions.		Quantity Required.				Best Supply Available.				Power to be Utilised.					

Departmental Geology of England and Wales.] TABLE C.* [*To accompany Map.*

Department.	Counties.	TERTIARY, OR CAINOZOIC.																			SECONDARY, OR MESOZOIC.																					PRIMARY, OR PALÆOZOIC.																					
		Post Tertiary.				Eocene.										Cretaceous.					Jurassic.													Triassic.			Permian.				Carboniferous.			Devonian.			Silurian.											Eruptive Rocks.					
		Post pliocene.		Pliocene.		Upper.				Middle.		Lower.				Upper.			Lower.			Upper oolites.		Middle oolites.		Lower oolites.					Liassics.						Upper.	Middle.	Lower.					Devonian, or old red sandstone.			Upper.			Middle.	Lower.			Primordial.									
		Post glacial.	Glacial.	Red crag.	Coralline crag.	Bembridge beds.	Headon beds.	St. Helen's beds.	Osborne beds.	Barton beds.	Bagshot beds.	London clay.	Woolwich beds.	Reading beds.	Thanet sands.	Chalk.	Greensand.	Gault.	Neocomian.	Wealden.	Purbeck.	Portland beds.	Kimmeridge clay.	Coral rag.	Oxford clay.	Cornbrash marble.	Forest marble.	Great oolite.	Inferior oolite.	Middle oolite.	Upper lias.	Lower lias.	Avicula contorta beds.	Keuper beds.	Muschelkalk beds.	Bunter.	Magnesian limestone.	Marls.	Sandstones.	Coal measures.	Millstone grit.	Carboniferous or mountain limestone.	Lower shalls.	Upper.	Middle.	Lower.	Ludlow series.	Wenlock series.	Woolhope limestone.	Llandovery series.	Caradoc beds.	Bala beds.	Llandeils flags.	Tremadoc slates.	Lingula flags.	Cambrian.	Laurentian.	Granite.	Syenite.	Felstone dykes.	Basalt.	Greenstone.	Metamorphic rocks.
N.	Northumberland ...																																							+	+	+																			+	+	
	Cumberland ...																																				+	+	+	+	+																						
	Westmoreland ...																																					+	+	+																		+					
	Durham ...																																				+	+	+	+	+	+																					
N.E.	Yorkshire:—E. Riding		+													+	+		+				+																																								
	N. Riding																							+					+		+						+				+	+																					
	W. Riding																												+								+			+	+																						
N.W.	Lancashire ...																																	+		+			+	+	+																						
	Cheshire ...	+																																+		+			+	+	+	+																					
	Denbighshire ...																																							+		+						+	+														
	Carnarvonshire ...	+																																														+					+	+									
	Anglesey ...																																																														
	Flintshire ...																																							+		+														+							
E.	Lincolnshire ...															+	+		+				+																																								
	Rutlandshire ...																									+					+	+																															
	Norfolk ...		+	+												+	+																																														
	Suffolk ...		+	+	+										+	+																																															
E.M.	Derbyshire ...																																	+		+		+	+	+	+	+																					
	Nottinghamshire ...																															+	+	+			+	+	+	+				+																			
	Leicestershire ...																															+		+		+			+	+																	+						
	Northamptonshire ...																								+	+		+	+		+	+																															
	Huntingdonshire ...																+							+	+	+		+	+										+		+	+																					
	Cambridgeshire ...																+	+																																													
W.	Merionethshire ...																																															+		+	+	+											
	Montgomeryshire ...																																																	+		+											
	Cardiganshire ...																																																	+													
	Radnorshire ...																																											+		+		+		+			+										
	Pembrokeshire ...																																																	+			+										
	Carmarthenshire ...																																													+				+	+	+	+			+							
	Brecknockshire ...																																											+		+																	

W.M.	Staffordshire																																					+	+	+								+															
	Shropshire																																+		+								+		+	+	+		+	+	+	+			+								
	Warwickshire																																+					+																								
	Worcestershire																																+		+			+	+								+	+															
	Herefordshire																																										+		+	+			+															
E.	Bedfordshire															+	+	+					+		+	+		+																																			
	Hertfordshire											+	+	+		+																																															
	Essex			+	+							+	+	+	+	+																																															
	Middlesex										+	+	+	+		+																																															
	Surrey										+	+	+	+	+	+	+	+	+	+																																											
	Kent											+	+		+	+	+	+	+	+																																											
S.	Oxfordshire											+		+		+	+	+			+	+	+	+	+	+	+	+	+	+	+																																
	Buckinghamshire		+									+		+		+	+	+			+	+	+		+	+	+	+		+																																	
	Berkshire										+	+		+		+	+	+				+	+	+	+																																						
	Wiltshire	+															+	+	+				+	+	+		+	+																																			
	Hampshire					+	+	+	+	+	+		+			+	+			+													+																														
	Dorsetshire															+	+		+	+	+		+						+																																		
	Sussex										+		+			+	+	+	+	+	+										+																																
S.W.	Glamorganshire																																						+																								
	Monmouthshire																																			+																											
	Gloucestershire																								+		+			+	+		+						+										+														
	Somersetshire																											+	+	+	+		+						+						+																		
	Devonshire	+															+	+																									+	+	+																		
	Cornwall																																										+	+	+																		

* Compiled and abstracted from—R. Tate's "Geology;"
Sir Charles Lyell's "Geology;"
Maps and Reports of Rivers Pollution Commission (Map by E. Best, Esq.);
"Geology of Counties of England and Wales," by W. J. Harrison, Esq.

TABLE D.

Staff Required in Departments for the National Hydraulic Board or Commission.

1. Survey:—

To make complete levels of departments and districts.

2. Hydraulic or Engineering:—

To report on present resources, including wells, lakes, rivers, and streams. Also to give accounts of existing works and machinery;

To determine upon and supervise execution of future works.

3. Statistical:—

To report on population, habitations, factories, quantities required, and to compile statistics generally.

4. Mechanical:—

To report, advise, determine on, and take charge of machinery.

5. Geological:—

To report fully on the hydro-geology of all districts.

6. Chemical:—

To give analysis of various waters, &c., as may be necessary.

7. Meteorological:—

To report on rainfall of each districts, with account of mist fall on hills, and wind pressure of the nation.

8. Finance:—

Including Assessors, Collectors, Accountants, and Paymasters.

Summary of Suggestions.

A. To take a full account of the requirements and condition of the peoples.

B. To take an account and to consider the best and most available resources for the work.

C. To draw out the plan of division and of district and department works.

D. To carry out the work.

E. To appoint means for payment.

F. The statistics and particulars to be taken for every place—as for a single place now—this is absolutely necessary.

G. The present statistics are not sufficient, being too general.

H. The requirements should be anticipated for 60 or 70 years.

I. The Ordnance Survey should be completed without delay.

J. A National Hydraulic Board should be appointed.

K. Every water supply should be under Government inspection or supervision and control.

L. Mist-fall and wind-pressure records should be taken.

M. Whatever divisions are now made, they will have to be modified as parts of a whole scheme.

N. No one arrangement will be found suited to every condition.

O. The country should be divided into departments and districts.

P. The departments may be as Map, and Form B.

Q. The department Board to decide what is to be done.

R. A law must be made to give powers.

S. Sketches of requirements to be embodied in Bill.

THE INCIDENCE OF RATING FOR SANITARY PURPOSES IN RURAL DISTRICTS.

By A. H. Brown, M.P.,

Vice-President of the Society of Arts.

In rising to bring this subject before the Conference, I feel that it is one of considerable magnitude, and one on which I am afraid there is some difference of opinion. For some years I have been watching the working of the Public Health Acts in the rural districts, and have endeavoured, if possible, to find remedies for the difficulties, where there appeared to be need of a remedy. I have now to bring before the Conference a point which I feel sure is one of the great obstacles that prevent the successful working of the Public Health Acts. Sanitary improvement, like every other improvement, cannot, I am afraid, be carried on without money. The way the money is raised for certain sanitary purposes is the reason why I ask the Conference to grant me their attention for a few minutes. I ask them to consider the incidence of rating for water supply and drainage, and whether a better incidence of rating cannot be devised. Let me say, at the outset, that I have no intention of raising the question of rating income; what I want is the proper apportionment of the expense on houses and lands. I hope gentlemen who follow me will keep to the narrow issue I have raised. The present mode of raising money for sanitary purposes is that an area is taken—such as a parish—and upon that area a rate is laid, which falls equally upon all the property within the area. There is an exception in the case of agricultural land, about which I shall speak presently. In some cases there are special drainage districts; but I shall show that they do not meet the difficulty. I may mention that urban districts have the power of making a separate assessment upon a part, or parts, of the district. Now, if all the property within the area were equally benefited by a sanitary improvement, the plan of levying an equal rate would be fair; but, in almost all cases, some property is not benefited at all, or only in an indirect manner, while other property receives the full benefit. Take the case of a parish with a village, which has to be drained or supplied with water, in the centre or at one end, and with a lot of agricultural land around it. Is it right or fair that all the land should be rated for the drainage water or supply of the village? Or take the case of a parish with two villages, one of which is to be drained or supplied with water; is it right that the other should help to pay for the cost? Or take the case where there are two landlords; one an improving landlord, the other not. Is it fair that the first, after he has improved his own property at his own expense, should have to pay for the improvement of the property of the other? Or, if you take another case, where a speculative builder has run up a lot of houses, is it right that the cost of draining those houses should be borne by the parish? What do we find actually to take place? In parishes where any sanitary improvement is to be effected, there immediately spring up two parties, one for, and the other against, the proposed works, those whose houses are not going to be benefited objecting to pay for the improvement of their neighbour's property. A case of this sort was mentioned by Colonel Cox, of the Local Government Board, when he gave his evidence before the Select Committee of last year on the Public Health Act Amendment Bill. He said, in answer to a question put to him—

> "I have one case particularly in my mind that occurred very recently, but it is not by any means an uncommon one. It was a question of supplying with water a small village called Tal-y-Bont in Brecknockshire. The village of Tal-y-Bont was at one end of a contributory place some 12 or 13 miles long; it contains about one-third of the population of the parish; the remaining population—that is to say, the two-thirds not in the village—occupied detached houses and farms. Opposition was most vigorous, and not unnaturally so, on the part of those people. They said, 'We two-thirds have got to put our hands into our pockets and pay for the express benefit of the remaining one-third; and those people whom we are supplying with water are perfectly well able to supply it for themselves, and the whole thing is wrong.' The opposition was extremely fierce and obstinate on those grounds."

Many other instances were mentioned by Sir Baldwin Leighton and others, of villages where the population was seattered over a large area, and where those who were not benefited by the im-

provements objected to pay. With regard to this state of things, the Committee of last year reported that it was productive of grave evils. The report says:—

"It frequently happens, notably in rural districts, that the whole charge is borne by the parish, under the rate for special expenses, while the supply of water is limited to the village, or a particular part of the parish. Those, therefore, who live outside the village, or the part of the parish benefited by the supply, have to pay for the water from which they derive no advantage; this fact causes great opposition to schemes for water supply, and in many instances renders it impossible to carry them out."

The same reason prevented the execution of drainage works. The Committee, to which I have referred, had before them the evidence of Dr. Ballard, of the Local Government Board, who was able to mention case after case, where villages required draining, and where the public health had suffered in consequence of nothing having been done in the way of drainage. Why was this? The reason was, because those who administer the law knew that great opposition would be raised, and not unjustly raised, if they attempted to levy a rate on all, which was only for the benefit of a few. Perhaps I shall be told that what is wrong is the area, and that the area ought to be altered. But in most cases, the area is the parish, and to alter the area of a parish for sanitary purposes only is impossible. They are very ancient, and so interwoven with what we call local government, that such an idea has only to be stated to show its impossibility. But I shall be told that there is a provision for making special drainage districts in the rural parts of the country. But these special drainage districts are found, in practice, not to work well. I have made inquiry on this point, and have received information from 105 medical officers of health, who have the supervision of 6,500,000 acres of land, and 2,000,000 of the population of this country in 37 out of the counties of England and Wales. Only 26 out of the 105 medical officers were able to say that application had been made to the Local Government Board for the formation of a special drainage district, some of which had been refused. On this subject, the report of the Committee of last year contained the following observations:—

"Special districts for drainage and water supply have been in some cases formed, but objections are often raised to the formation of new rating areas, and in some cases special difficulties arise; for instance, when in a village some of the houses have water and some have not, and when these two classes of houses are intermingled."

I think I have said enough to show that special drainage districts are not very successful. Let me now deal with the objection that the parish ought to pay, and that it must be treated as a whole. It is argued that the villages contain the labour which is used on the land, and therefore, it is fair to tax the farmers for the benefit of the labourers. But this is often not the case. The villages often have a special industry. Take, for instance, a mining country, or suburban places, where the labour belongs to the town. In such cases there is no benefit to the farmers, and their land ought not to be rated. Again, it is said that if the rates do not fall upon the parish, no sanitary improvement will take place; and, consequently, disease will spring up, and the poor rates will be increased. The answer to this is that, if you make the incidence of rating fair—which it is not at present—opposition to sanitary works will decrease, and, therefore, the public health will be improved. On this subject Sir Baldwin Leighton said:—

"Then there is the argument that the parish is interested in these improvements, because if they are not made, it will have to pay for medical relief, if not for pauperism. That I think is a fallacious argument. The other argument is that the village contains the labour of the district and, therefore, that the surrounding land ought to pay for it; but that I think is as great a fallacy as the other. In the first place, the village does not contain that labour; in my part of the country it hardly ever does; the labour is contained either in the farmhouses or in detached cottages. There are instances of suburban villages where the labour really belongs to the town, and not to the country; but being in the district of the rural authority, it would be thrown upon the parish."

Having shown that there is a great opposition to works for sanitary purposes, and that there is nothing in the present law to remove the opposition, I come now to suggest the remedy. In dealing with the question of water supply, the Committee stated in their report that, after full consideration, they—

"Think that the sound principle to lay down is that the water supplied by a sanitary authority should be paid for by the consumer. It is obvious that a fair charge made directly on the houses benefited will tend to disarm the opposition which now arises on the ground that the cost of the water-works will be thrown on the rates."

Let the same principle be applied to drainage; and when a house is drained, let the cost of the works be a charge upon the house which is benefited. But I shall be told that this would require a great alteration in the law of rating. No doubt this is true; but the principle is not new. The principle is found in the Public Health Act itself as regards nuisances; for the cost of removing a nuisance is borne by the property to be benefited by the removal of it. The same principle is in operation with all water companies, for there the cost of water is paid for by the consumers. As regards drainage, we find the same principle adopted in many Acts of Parliament. It is admitted in the Public Health Act; for under the provisions of this Act it is possible to charge the property benefited with the cost of the works in some cases—I mean those cases in which a private improvement rate is levied. It is also admitted in various local Acts, thus pointing conclusively to the policy of extending the principle I contend for into general law. For instance, in the Hereford Improvement Act, 1872, I find the following power to levy sewer rates. I need not read the whole of the section—the important part of it is that—"A sewer rate is to be levied upon the houses, lands and tenements, the drainage of which is connected by pipes with any such sewer or drain;" and in order to make it perfectly clear what the rate is for, the section concludes by stating that the rate is to be in lieu of any rates for making sewers under the authority of the Act of 1854. Again, I will quote the case of a

large town—Liverpool—where part of the cost of the sewers falls directly upon the house drained by them. The Liverpool Sanitary Act says as follows:—

"Be it enacted that when and as soon as any such house or building shall drain into or communicate with any sewer vested in the Mayor, Aldermen, and Burgesses, the owner of such house or building shall pay to the Council a sum after the rate of six shillings for every lineal yard of the frontage of such house or building towards the principal street in which the same shall be situated."

I am aware that there are difficulties in the plan adopted in this case; but the principle is the same. Again, to quote from one more local Act—the Blackrock Local Board Act, 1876, has the same principle with regard to water. A section of the Act is as follows:—

"The Local Board may demand and take for the supply of water for domestic purposes within the district any rates and charges not exceeding the rates and charges following, that is to say, where the annual rack rent or value of the premises so supplied with water shall not exceed twenty pounds, at a rate per centum per annum not exceeding seven pounds ten shillings."

As the power of rating is here limited to premises supplied with water, it is evident that they cannot rate premises not so supplied; or, in other words, the Board are recouped for their expenditure by charges on the property benefited. I have noticed that there have been several allegations against the principle I have laid down, and these I will now glance at. First, it is alleged that the proposal would exempt agricultural land from rating, and that already this class of property is partially exempt, being rated at only one-fourth of its value, and in this manner it already enjoys an unfair exemption, for it ought to pay more than it does to the highway rate. The answer to that is this—that each rate should be considered on its own merits, and in relation to the public good to be effected; and it is no answer to say that one can be put off against the other.

But I shall be asked whether this principle extends to urban districts. In any closely-built town you find the principle I am contending for is in operation, for every house being drained or supplied with water by the public authorities has the benefit of such water and drainage, for which it has to pay the rate. These are border cases, districts which have urban powers, but are rural in their characteristics; and I, for one, do not deny that there is considerable difficulty in dealing with them. Again, it is said that it would destroy the security on which money has been lent—I mean the security of the rates of the whole parish. But that is not the case, for the rates of the whole district would be the ultimate security, and would be mortgaged, though the rates on the property benefited would be the first asset for the repayment of the interest and principal of the mortgage. With reference to the objection that, under the proposal I make, the areas might be very small, and, therefore, the rating might be high, I think the objection is a good one in those cases where, from various circumstances, the cost must be great; and, therefore, I think it would be necessary to put a limit of charge upon the property benefited, and any excess of charge should fall as it does now. This is a difficult and technical subject, and I am afraid I have failed to put it clearly before the Conference.

The object I have in view is to diminish the opposition which, at present, exists to sanitary improvements in rural districts, and this object I believe can be attained by relieving ratepayers from the injustice of contributing to improvements by which they are not benefited. If anything in this direction could be effected, I believe it would be a great improvement; and, therefore, I have brought the subject before the Conference. One further remark I would make before sitting down. It appears to me easy to see how the present state of the law has arisen. Sanitary legislation has been a system of growth. The wants of populous places have received first attention, while those of thinly inhabited districts have been neglected; and we have made the mistake of applying to a thinly-inhabited district the laws which should apply to a more complex form of society. It would, I think, have been more scientific if the wants of a simple form of society had first been attended to, and afterwards there had been grafted on to those principles the developments necessary to a more complex form of society.

THE UTILISATION OF THE WATER SUPPLY OF ENGLAND.

By Francis R. Conder, C.E.

At the time when public attention in England was sharply directed to the sanitary condition of the country by the serious illness of H.R.H. the Prince of Wales, in 1871, the writer submitted to the Local Government Board a plan for the sanitary and hydrographic survey of the country, and for the division of England into an organised system of districts for that purpose. For this plan, that of the creation of independent and disconnected local authorities was unfortunately substituted by the Government, and the opportunity for efficient organisation was thus thrown away. In July, 1873 (with the assent of the President of the Local Government Board), an article to some extent sketching out the original scheme was published in the "British Quarterly Review," and from that date the subject has from time to time been advocated by the writer in different publications.

On the appearance of the letter of H.R.H. the Prince of Wales to the Chairman of the Society of Arts, dated 30th January, 1878, the writer, referring to the above facts, submitted a paper on the water supply of England and Wales (accompanied by a map), which the Prince sent to the Council of the Society. The paper is printed on p. 40 of the official account of the Congress held in May of last year. From the same report it appears that the writer proposed that the result of the discussion then pending should be put in the form of a resolution, which suggestion was at once adopted by the Chairman; and a motion to that effect, framed by the Council, was moved on the 22nd May by Dr. Wright, seconded by the writer, and carried unanimously. This resolution recommended the Council of the Society to make application to the Government to appoint a commission to investigate and collect the facts connected with water supply in the various districts throughout the United Kingdom.

The invitation by the Council of the Society of Arts of suggestions for the division of England into watershed districts, can only be properly responded to by bearing in mind the conclusion thus arrived at—that of the pressing need of a complete hydrographic survey of the country. In the absence of that indispensable information, the reply of the engineer to such questions as those proposed can only be, to a certain extent, guess-work.

Indeed, the President of the Institution of Civil Engineers replied to the inquiries of the Council of the Society of Arts, in the spring of 1878, that he saw no way in which a large and comprehensive scheme of a national character could be brought forward, owing to the difference of condition in different districts. This rather discouraging opinion was published by the Council.

Of the other papers brought before the Congress (on 21st and 22nd May, 1878) that of Mr. Brown, M.P., called attention to the provisions of a Bill he had introduced into Parliament for the amendment of the Public Health Bill. Mr. J. W. Willis Bund proposed the appointment of a proper body to watch over the water supply, and the provision of funds to carry out the plan. The Rev. J. C. Clutterbuck insisted on the necessity of an extended and accurate knowledge of the amount and distribution of the rainfall of England, including the absorption of water by impervious strata. Sir Henry Cole thought that the whole kingdom might be mapped and parcelled out into a sort of water heptarchy. The writer gave a brief sketch of the main features of the inquiry, and of the division of England into chief outfall provinces. Mr. Bailey Denton expressed his view of the necessity of a conservancy of river basins, of the acquisition of a knowledge of their hydro-geological conditions, and of the provision of legal facilities for dealing with the water. Mr. De Rance pointed out that the sanction of private applications for Acts of Parliament for water supply, in the absence of a general survey of the country, might be very mischievous, and gave a table showing the chief geological formations of the river basins on the northern, eastern, southern, western, Welsh, and north-wests coasts of England. Mr. Evans called attention to the sources of subterranean supply. Mr. Hassard spoke of the Welsh gathering grounds. Mr. Homersham dwelt on the advantages to be secured by the educated engineer from the careful study of data. Mr. Lucas urged that the general absence of data as to water was the only real difficulty in the case; and that a national survey would provide the remedy. Mr. Parry proposed the division of the country into watershed districts, each under the charge of an engineer, and suggested the existence of 25 watersheds, each exceeding 500 square miles. Mr. Pierce argued as to the necessity of a national supply of water, and that to be provided by the Government, instead of by the Local Boards. Mr. Prestwich took a general view of the water-bearing strata of the country. Mr. Shelford suggested that power should be given to county Boards to deal with the catchment basins, of which he enumerated 215. Mr. Shute spoke of artificial lakes, but gave no figures. Mr. Symons referred to the rainfall statistics, and recommended that the entire administration of streams should be brought under a single direction. Mr. Wills pointed out the inadequacy of local authorities to deal with the question of water supply.

Thus, the whole *consensus* of the proposals of 20 different scientific men, sent in without any mutual knowledge, follows the lead of the proposal made to the Local Government Board by the writer in 1872; and the resolution of the Congress added the sanction of the unanimous consent of all its members. The utter ignorance in which engineers now are of many of the actual facts —as admitted by the president of their Institution —the imperative need for their collection; the necessity of Government impulse and direction for such a collection; and the propriety of dividing the island into national watershed and outfall districts; must be taken as points which it is no longer requisite to discuss.

Such being the present state of the question, it is evident that the suggestions that can now be usefully submitted to the Council of the Society of Arts must be limited in their range. It is unnecessary to urge further the need of information, and it is useless to attempt any detail of recommendation in the absence of the requisite data.

It may, however, be of use to say something as to the principle of the watershed divisions of the country, and also of the steps which it is competent for the hydraulic engineer to take, if called on to advise in any particular line.

From the fact that the entire water-supply of the country originally descends upon its surface in the form of rain, snow, hail, or vapour, it follows that the first duty of the hydrographer is to ascertain the lines of watershed or water-parting; and then to measure the quantity of rain which annually falls in each district thus physically divided by nature. The lines of water parting will not be, in all cases, exactly those of the summits of the hills. But in the first instance the latter, forming the orographic divisions of the country, require to be clearly mapped out. The lines of watershed once defined, the next steps will be to measure the rainfall within each district, and then to ascertain what becomes of the whole.

The physical form of Great Britain (with the portion of which island forming England and Wales we only have now to do) indicates the primary division of the outfalls of the eastern, the southern, and the western coasts. The great central line of hills called the Penine chain, running from Warwickshire to Scotland, forms one primary watershed line. The Cotswold range divides the affluents of the Severn from those of the Thames. A more detailed study is needed to indicate the division of the head waters of the large basins of the Ouse and the Trent from the affluents of the Thames and Severn. The line of chalk downs running from Deal to Devizes divides the Thames catchwater basin from the sources of the southward trending rivers that fall into the English Channel. The granite upheavals of Devonshire and Cornwall divide the rainfall of the western prolongation of the irregular form of the island, between the English and the Bristol Channels. The Welsh mountain streams, whether turning off their rainfall to the east into the Severn, the Dee, and the Mersey, or directly westward or southward into the sea; and the rivers of Lancashire and Cumberland, drain the western portion of our coasts.

In descending from this general physical division of England to the smaller watershed divisions, there is room for some difference of opinion. The unit of the water system is a river basin, included between the watershed and the sea. But these units differ so extraordinarily in size, that some mode of grouping them becomes a matter of administrative convenience, or even necessity. Thus, while one engineer has sketched out 10 main outfall provinces, Sir Henry Cole has spoken of a water heptarchy. Mr. De Rance has tabulated 14 river systems, under six general heads, and Mr. Shelford has enumerated 215 catchment basins, which vary in area from under 100 to above 6,000 square miles. It is evident that administrative convenience must be consulted fully as much as absolute principle in carrying out the first general division of the rain outfall of the island.

With regard to the three largest of these districts, there is little room for hesitation. The Ouse and the Trent with their affluents drain an area which Mr. De Rance estimates at 9,457 square miles. The Thames and its affluents, including the Medway, drain an area estimated by Sir Henry James at 6,160 square miles. The Severn and the Wye, are estimated from the Ordnance map, by Mr. De Rance, as draining 9,248 square miles. Thus these three easily distinguishable systems comprise an area of 24,865 square miles, or 40 per cent. of the whole map of England and Wales. The definition of these watersheds at once fixes the boundary of other districts, and indicates the respective magnitudes into which it will be convenient to distribute them.

The east coast of England, after the abstraction of the outfall of the Humber and the Thames, is naturally divided into two districts, one lying north of the first system, and the other intermediate between the two. The basins of the Tweed, the Tyne, and the Tees contain, according to Mr. De Rance's tables, 3,702 square miles. The rivers discharging into the Wash, drain 5,828 square miles, according to Mr. Sketchley, and together with the remainder, flowing from the eastern counties to the north of the Thames watershed, drain in all 10,053 square miles, being an area nearly 200 miles in excess of former estimates. If the whole of the western promontory of the island be included with the western outfall from the south limit of the Thames basin, the area will be 8,350 miles. The rivers of the Welsh coast, westward of the outfall of the Taf and the Ely, into the Severn estuary, drain 4,378 square miles of country. The eighth district, in this order, is that drained by the Dee, the Mersey, and the Duddon, comprising 4,556 square miles. And the remainder of the western coast, from the Esk to the Eden, is confined in the comparatively small area of 1,758 square miles, which might, it is possible, be conveniently placed under the same administration as the first district, or that of the Tweed, Tyne, and Tees.

The divisions thus indicated differ from the sketch plan submitted to H.R.H. the Prince of Wales, only by the substitution of the measurements taken by an officer of the Geological Survey for the round figures taken from less accurate maps, and by a slight change in some of the distributions then made (such as that of the allotment of the Usk to the Severn system), for the sake of adhering to Mr. De Rance's measurements. The total area thus accounted for is 57,374 square miles. The total area of England and Wales, according to the agricultural returns, is 58,311 square miles; which figures were taken in the sketch distribution of May, 1878. The smaller total is now adopted, in accordance with the tenor of the invitation of the Council, "founded upon evidence already published."

Subject to such minor questions, and to the decision, as a matter of convenience, on the adoption of 10, 9, or 8 divisions of the country, the above consideration must regulate the main lines of demarcation between the natural outfall districts of England. It is now desirable to inquire how the meteorological and geological portions of the inquiry are to be connected with the first sketch, taken from the physical geography.

The problem which the hydraulic engineer has to solve in any particular case may be regarded as threefold. It regards the quantity, the quality, and the cost of the supply. These elements depend on area of watershed, or quantity of rainfall, and on character of soil, not only orographically, but geologically, regarded.

As regards the first question, that of quantity, the first index to be offered to the engineer is the hydrographical map of the British Isles, prepared by Mr. G. J. Symons, a copy of which will be found in No. 66 of the "Transactions of the Institution of Surveyors." The annual report on British rainfall should be studied in connection with the map.

It will be seen from these authorities that the water supply of England is divided—as in the first instance we considered the water outfalls to be—into three districts, corresponding to the *quasi*-triangular form of the island. The rainfall is, however, heavier on the more elevated districts of country. It is more on the south coast than on the east, and more on the west coast than the south. The ten rainfall districts, or registration divisions of Mr. Symons, unfortunately do not coincide with the natural river outfall districts; the divisions of the Registrar-General, which are not based upon physical geography, having been adopted. The first requisite for making the best use of the observations already collected, as well as for completing them when requisite, will be the adaptation of the registration districts to the outfall districts. As to this, Mr. Symons is fully aware that it is desirable. But it is a costly process for an unsupported institution to undertake, and is one of the points which can only be thoroughly carried out as a part of the complete survey. In the meantime the approximate method of distribution which was applied in the author's sketch map of 1878, will have to be more minutely applied by the engineer in any district in which he is engaged.

Area, levels, and main rainfall being ascertained, the nature of the soil furnishes the next grand division of the subject. Soils, in principle, are either impervious, pervious, or partially pervious. From impervious soils the rainfall escapes in floods or torrents. In these formations are also to be found the great sub-aerial reservoirs of water known as lakes.

The question of the greater or less perviability of the soil is matter of special study. In principle, the pervious strata may be divided into those which, owing to their local and physical charac-

teristics, absorb rain and yield it again in springs, brooks, or rivers, and those which, conveying the water they imbibe to a more considerable depth, carry it under ground to the sea, thus yielding a supply only accessible by wells, perhaps of great depth.

On the eastern coast, the lower carboniferous strata, the coal measures, and the magnesian limestone, tend to give the character of torrents to the rivers of our first district. The Lias, the Oolite, and the boulder clay then line the shore, to which the cretaceous beds approach near Flamborough head. The Trent and the Ouse drain 4,000 miles of permeable, as well as 3,500 of partly permeable, strata; and the hydrography of the district affords a sharp contrast to that of the more Northern division. The rivers that enter the Wash drain a large area of aluvial deposit, and are fed from the chalk and the oolite springs, as well as by torrent waters from the Lias. The Thames derives its head waters from the Oolite and the chalk, while the tributaries to its stream, in the lower part of its course over the tertiary clays, are torrential. The cretaceous and Lias beds, and tertiary deposits, line the southern coast, as far as the constriction between Lyme Regis and Bridgewater. Granitic, Cambrian, and Silurian rocks, impermeable or only partly permeable, send down the swift bright rivers of Cornwall and of part of Devonshire; though the Exe meanders through a district resembling that drained by the Warwickshire Avon. Severn receives contributions from almost every geological system; and having cut a deep narrow channel in the broad rich valley, which forms its bed below Worcester, affords an example, rare in England, of an annually enriching, and usually harmless, natural inundation. Great geological variety, on passing west and north of the estuary of the Severn, demands careful study. From 40 to 75 inches of rainfall rush down the slopes of the clay slates, trap rocks, and Devonian strata of Wales. The Mersey and the Dee drain a district not unlike that which is watered by the Trent; and north of the Ribble we again touch the torrential district of the lakes.

From this glance at the different physical conditions of the main outfall provinces of England, it will at once become apparent that any suggestions as to the further subdivision of the country into water supply districts, must, until the hydrographic survey is complete, either be brief and general, or partake of the nature of a treatise on hydraulic engineering. As the Society of Arts inserts, not volumes, but suggestions, the remarks which follow must be somewhat concise.

It will scarcely be disputed that, if an engineer be called on to advise on the water supply of any locality, his first duty will be to provide himself, as far as possible, with precisely that information which would be furnished by the general survey, if complete. Each locality must be regarded as forming an integral portion of the natural outfall district in which it is situated. Then the engineer will have to ascertain the area, as well as the physical, geological, and meteorological particulars, of the whole portion of the vicinity that lies between the locality he has to take in hand and the watershed of the basin. He will no less have to ascertain the natural capacities of the rivers, or other means of drainage, that will remove the water when supplied. It will be needful, in the first place, to ascertain the population of the district, and the probable increase, for at least, 30 years. The rough rules of 50 tons of water per annum for each unit of the population, and of 100 tons of water for every inch of rainfall, will give a first approximation between supply and demand. The annual rainfall, the annual evaporation, and the absorbent or non-absorbent character of the soil over the area on which the locality can naturally draw for supply, must be ascertained. Due care must be taken not to rob the gathering grounds of other towns or villages. The transgression of the natural watershed of a district is—unless there be special ground for exceptions—scrupulously to be avoided, both on the ground of cost, and on that of the propriety of allowing each the guidance of nature in the supply of its own district to follow need.

When such general observations have been made, the special character of the district will require study. Thus, in a mountainous country of impervious strata, natural or artificial lakes may form the most efficient means of supply. In more permeable soils the natural resources of springs or brooks may be utilised; or enough water may be procured (as in the case of the East Kent Water Company) from deep wells. In impervious soils the water will generally have to be led from some distance, or procured from deeper wells than is requisite on permeable soil; as in the case of penetrating the Lias into the abundant water-bearing strata found to underlie it. In cases where the subterranean supply is derived from the chinks or crevices which occur in the lower chalk, the greatest care must be taken lest sewage pollution damage the supply. No less care will have to be exerted as to springs, brooks, and rivers, whether in the upper or lower portion of their course, with reference to the country which it is proposed to water and to drain. The aim of the engineer will always be to take his supply, if practicable, on such a level as to allow of constant service by the action of gravitation; and even if pumping be in the first instance necessary, the position of the reservoirs should be fixed at such a height as to ensure that this mode of supply should not be neglected. Questions of economy as to position of reservoirs, length of pipes and culverts, cost of pumping, and other details of distribution, will require special treatment in any case. The chief rules will be to ascertain the natural source of supply, to utilise it with due regard to all claimants, and so to balance the question of head and of lift, as to ensure the truest economy, combined with the greatest certitude of efficient supply.

By this careful treatment of any given locality in England, with due regard to its position, in any of our outfall districts, the special survey for individual cases may be so carried out as to form data for co-ordination hereafter in the general hydrographic survey. It is by this method alone that, pending the completion of the national work, individual improvements can be effected without incurring the risk of being hereafter found impediments to the general improvement of the district in which they occur. An ill-arranged local water supply, that should rob a more important district of its natural sources, that should interfere with the drainage of a valley, that should

waste surface or subterranean stores, or that should poison rivers or land waters below the area, would become a dangerous nuisance, and ultimately a great source of expense.

The town of Guildford may be cited as an illustration of the truth of the above remarks.

Guildford is situated at the spot where the River Wey finds a passage through the long rampart of chalk that extends across Surrey in an easterly and westerly direction. Part of the town is situated on the chalk, along the axis of the downs, and part along the valley of the Wey. Both parts of the town were formerly well supplied with water from wells sunk in the chalk, and in the alluvium of the valley; and the Wey brought a copious supply of fresh water to the very doors of the lowlying houses. Guildford, however, is not sewered. With the increase of the population, the wells became polluted by sewage matter. In the lower chalk the water makes its passage through chinks, and the sewage does the same, without oxidation. Typhoid fever became more and more prevalent, until some years ago the matter was thoroughly taken in hand. A well was sunk, for 30 feet below the level of the river, into the water-bearing stratum of the Folkestone beds; and a copious supply of pure water was pumped up to a reservoir on the hill. The town is now supplied with the most unexceptionable water, and has become perfectly healthy.

In this case it is clear that, while a thorough local knowledge was necessary, as pointing out the dangerous state to which the water-supply, on which the town had subsisted since the time of Alfred, had been brought by the growth of population, the scientific knowledge of the position of the locality in the limits of the Thames watershed basin pointed out the remedy. The watershed above Guildford covers an area of 230 miles. It was observed, during the progress of the Ordnance Survey, that not more than two-fifths of the rainfall over this area ran under the bridge at Guildford. A large proportion of the rain permeates the Folkestone beds, composed of ferruginous sands, which attain a thickness of 160 feet at Godalming, four miles above Guildford, and form a persistent stratum beneath the Gault. The body of water which thus flows towards the Thames is probably arrested and diverted seaward, by the palæozoic anticlinal which has been recently discovered. An ample supply for the south of London is neglected; but its source has been taken advantage of at Guildford with the best results. One example may be enough to show the application of the principles, as to the truth and range of which it is submitted that there is no longer room for doubt or debate.

THE WATER SUPPLY OF LARGE TOWNS.

By the Rev. James C. Clutterbuck.

The "Notes on Previous Inquiries on Water Supply" invite remarks on the future as on the past, All water supply, whether surface or subterranean, whether naturally issuing from springs, or artificially reached by wells or shafts, is derived from rainfall; hence the value of the reports issued by the Meteorological Office, and the records of Mr. Symons and others, by which the amount and distribution of rainfall in various districts is determined. This natural supply cannot be augmented, and must, moreover, be estimated not on the average of years, but by a minimum which, year by year, is more heavily taxed to meet the wants of an increasing population, whose sanitary requirements require increased quantities, and purer qualities to be provided, and this not only for large towns, but for villages throughout the country, This is the problem which it is the object of this Congress to solve. The important question of water supply resolves itself into the economical use of quantities more or less ascertained. The metropolitan water supply, which from time to time is under discussion, is not only an important but an anxious subject of inquiry. Within the memory of men now living, the older parts of London, placed on a bed of gravel, resting on the clay, pierced by numerous wells, yielded a large amount of water. The sanitary requirements of the inhabitants has put a stop to the use of this source of supply. As late as 1834, it is stated in Telford's Report on the metropolitan supply, that the Grand Junction, West Middlesex, and Chelsea companies distributed only 6,810,000 gallons per diem, a quantity utterly insignificant as compared with the present quantity which these companies deliver.

The gradual depression of the water level in artesian or artesioid wells under London, has proved the impossibility of relying on that source for any increased supply; and may furnish a warning against trusting to artesian wells as a perennial source from such wells beyond the limits of the metropolis. The schemes for bringing water from the lake districts present difficulties not easily overcome. Not to enter into their consideration at length, yet, judging from the published reports, I am not aware that the perennial yield from these sources has been duly tested, by gauging the streams for a series of years, which issue from the lakes whence it is proposed to draw the supplies. The volume of the Thames, on the other hand, is well known, and as it derives the greater portion of its water from the chalk formation, almost from its source, there is no reason to believe that this, as a perennial supply will ever fail, though there is a yearly increased quantity taken by the towns on its banks. Though it may seem an insignificant quantity; in case of drought the consumption of water by railway, agricultural, and other engines is worthy of notice. The difficulties of the water question in nearly all large towns is too well known to require much to be said. Liverpool has failed to obtain a supply from deep wells; Manchester is to depend on Thirlmere. Other large towns, having exhausted their natural sources of supply, need to be warned that no sources are without a limit, and, as before stated, all quantities must be calculated on a minimum to be ascertained, not by an average rainfall, but by careful gauging of the streams which issue from the lakes, which are counted on as perennial reservoirs. The general supply to villages and smaller towns present many difficulties. It will be found that these, especially the most ancient, are placed on sites where water is, so to speak, at hand. Too often, through negligence or ignorance, these sources have been polluted and made unfit for use; this makes it difficult to find fresh and wholesome supplies, added to which, those persons appointed as

sanitary inspectors seldom possess the knowledge necessary to determine questions of subterranean water. Though it must needs be attended with considerable expense to find duly qualified inspectors, this ought to be done to insure the knowledge of geology and engineering, indispensable in this matter. That there are many sources neglected which might be made available is beyond doubt; for example, Archdeacon Denison, as reported in a letter to the *Times*, secured for the village of East Brent, Somerset, a pure and abundant supply by intelligent observation, and at moderate expense. Other instances have come under my observation, but generally speaking the utilisation of the sources of water are beyond the powers of ordinary persons. A well qualified inspector might superintend a very large district, and, by advice and direction, secure supplies of water which had before been overlooked. This has frequently come under my own observation. A certain amount of geological knowledge is indispensable in this matter, and till such knowledge is duly brought to bear upon it, the question of water supply will not be duly understood or its difficulties solved.

PERVIOUS ROCKS OF ENGLAND AND WALES.

By C. E. De Rance, F.G.S., A.M. Inst., C.E.

(H. M. Geological Survey.)

In a communication the Committee did me the honour to bring before the Congress last year, I gave some statistics as to the extent of the chief geological formations, in 14 groups of river basins, into which I divided the 215 river basins of the Ordnance Survey Catchment Basin Map.

Since then I have made some further investigations as to the extent of the permeable and impermeable strata in each area, and also into the districts which receive underground drainage from other basins.

It will be noted that an important watershed crosses England diagonally from north-east to south-west, separating the basins of the Severn, Trent, &c., on the one side, from those of the Thames, east coast streams, Witham and Ouse on the other. This line nearly separates all the strata up to the top of the Trias, from the Lias upwards. Commencing on the chalk strata of the Isle of Purbeck, it ranges from Crewkerne, at the top of the Oolites across England, by Cheltenham and Chipping Campden, gradually resting on somewhat lower rocks. In advancing to the north-east, it passes over the Lias near Rugby, and reaches the Keuper marls at Gainsborough, where six square miles or so passes over the boundary, forming the only exposure east of that line. At Scarle, near Lincoln, and Burford, in Oxfordshire, the Trias has been reached and penetrated beneath the overlying Oolites, but south of the latter locality it probably thins out against the old palæozoic ridge underlying the Thames valley, connected with the Mendip range, which latter, though capped more or less by new red marls, was doubtless above water when the New Red Sandstone was deposited, and east of a line ranging through Gloucester and Stamford, the chance of the New Red or Permian being present in sufficient thickness to be water bearing, is very small.

In the Severn, and Avon basin, of the 1,831 square miles occupied by triassic strata, no less than 1,393 consist of red marls, much of which area is not suprapervious, resting on pretriassic impermeable rocks. The remaining 438 square miles of triassic sandstone absorb not less than 10 inches of rain annually, which is equal to a daily yield of 175 million gallons, or supply for 3½ million people at 50 gallons per head. The underground water of this basin will flow into the Trent basin between the north and south Staffordshire coalfields, in its northern area, and into the Thames basin in its southern area; but in the latter, from the southerly attenuation of the strata, this supply is of no practical importance.

South of the Mendip range in southern Somerset and Devon, triassic sandstones again come in beneath the marls, the former being 315 square miles in extent, and the latter 49 square miles. This area of sandstones, with 10 inch absorption, should yield a daily average of 126 million gallons, or supply for 2½ millions of persons, and is available for the supply of Exeter. In the valley of the Clywd, 40 square miles of triassic lower mottled sandstones occurs; it has been bored into to a depth of 600 feet, and rests on impermeable palæozoic rocks; it drains into the sea, beneath high water mark. In the Lancashire and Cheshire triassic plain, in the basins of the Dee, Mersey, and Ribble, occur 1,920 square miles of triassic rocks, of which 850 are red marls, for the most part salt-bearing, and of too great thickness to allow boring through to the sandstones beneath, which, however, crop to the surface over an area of 1,070 square miles, which, at 10 inch absorption, give a daily average yield of 428 million gallons, or a quantity sufficient for the supply of 8½ millions of people, at 50 gallons per head. The population of Lancashire and Cheshire, in 1871, was about two millions, so that the supply from this source alone is four times the demand. From these sandstones, more than six million gallons are pumped daily by the Liverpool Corporation wells off a very small area. Large supplies are also drawn for Runcorn, Widnes, Warrington, Stockport, Southport, Ormskirk, &c., water supplies. The underground drainage in the southern portion of this area is towards the Cheshire salt field, the top of the sandstone there being considerably beneath the sea level.

In the Tyne and Tees basin, 170 square miles of triassic rocks occur, about 100 miles being sandstone, and the remainder marl. The ground is low, and the Permian limestone, with thick salt beds, occur below, and no good supply of triassic water can be relied on.

In the basin of the Ouse, Trent, and Humber occur 3,041 square miles of triassic rocks, of which 1,870 are marl (200 square miles around Charnwood Forest resting on the older rocks), and 1,171 red sandstones, which, at five inches absorption, would give a daily average of 234 million gallons, or a supply for 4½ million persons. The population of Yorkshire, Nottinghamshire, Derbyshire, and Staffordshire, in 1871, which are mainly in this area, was 5¾ millions. The demand is here in excess of the supply. In the West Yorkshire area it is met by a

good supply of water from the elevated carboniferous tract forming the Pennine Chain. To the south a good supply is got from the Trias at Nottingham and other towns westward, but the supply is not satisfactory over a large part of the Staffordshire district.

As already stated, the diagonal watershed, passing across England from south-west to north-east, is situated mainly on the Oolitic strata. They only occur west of it in three areas, viz., 768 miles in the Severn and tributary basin, all of which drains underground into the Thames basin; 171 square miles in the Ancholme valley, draining naturally into the Humber; and 852 square miles in the Cleveland district of Yorkshire, of which 183 miles are north of the Trent basin, though the underground drainage flows into it.

The diagonal watershed nearly corresponds with the north-west boundary line of the counties of Lincoln, Rutland, Northampton, Oxford, Bucks, Wilts, and Dorset, the water falling on the Oolites in the basin of the Witham and Ouse of the first three of these counties, and Huntingdon and Bedford drains underground beneath the cretaceous rocks of Norfolk, Suffolk, and Herts, into the basin of the Thames and East coast. The watershed between the Thames and Ouse commences at a point on the diagonal watershed near Weedon, at the base of the Oolites; then it cuts across the strike of these rocks, passing over higher and higher beds until it ascends the chalk escarpment near Tring, where it travels north-eastward, and nearly follows the strike of the chalk, rising to an elevation of 500 ft. near Baldock, and, with somewhat diminished height forms, the central watershed of Norfolk and Suffolk.

The Oolites of the Thames basin occupy 940 square miles, those of the Witham and Ouse basin 3,701, those of the area lying west of the diagonal watershed 236 square miles, or a total area of 4,880 miles, the whole of the underground drainage of which gravitates to the Thames basin. Assuming that only one-third be pervious, or 1,626 square miles, and only five inches of rain annually to be absorbed, a daily yield will accrue of 325 million gallons, or a supply for six and a half million people. Probably, however, only a third of this amount can be obtained from the thinning of the Oolites under the overlying strata in the Thames valley, against the old Palæozoic ridge. The large yield obtainable is, however, proved by the great volume of the Thames head springs.

Of the 10,506 square miles of cretaceous rocks in England, only 1,329 miles occur west of the diagonal watershed, 999 being in Yorkshire in the Trent and Humber basin, 16 miles on the west of the line, but draining underground into the Thames, and 257 miles in South Devon, forming the Blackdown beds. In the Thames and east coast district not less than 4,000 square miles of pervious cretaceous rocks, receiving not less than five inches of rain annually, or a daily supply of 800 million gallons, it is readily understood with these figures how the dry weather flow of the Thames is kept up, by chalk springs, this yield is sufficient for 16 million people; and taking the Oolite supply, the total volume of water yielded by underground sources in the Thames and East Coast river basins may be taken at 1,125 million gallons, a supply equal to the wants of 22 million people, or nearly that of the total inhabitants of England.

The cretaceous rocks occupy 2,038 square miles in the Witham and Ouse basins, about 1,500 square miles being pervious. Those of the Humber and Trent basin have already been described.

The tertiary deposits are chiefly impermeable; they occur entirely east of the diagonal watershed, and occupy 3,333 square miles in the Thames and East Coast basins; they are everywhere supra-pervious, resting on the cretaceous rocks, now being bored into at their base by the New River and other companies, and long drawn on by the London brewers.

MISCELLANEOUS.

BRITISH TRADE WITH THE COLONIES.

The Statistical Abstract for the Several Colonial and other Possessions of the United Kingdom from 1863 to 1877 (issued by the Government this year) forms the text for an article in the *Economist* on the course of trade between this country and its colonies. One of the tables gives the population of each British colony as far as it is known; another gives the value of the imports (including bullion and specie) into these colonies from the United Kingdom, separated from the total imports. By combining the information contained in these tables we are able to see the proportion of the value of the imports from the United Kingdom to the total imports of each colony, and further, the value of the imports from the United Kingdom per head to the population of each colony.

This calculation shows that the imports from the United Kingdom to British India were, in 1877, three-quarters of the whole imports into that country, but that the value was only 4s. per head of the population. It shows that the same class of imports formed nearly half the total imports into the Australian colonies, but that they were to the extent of fully £9 per head of the population there; while in the case of the colonies in North America—the Dominion of Canada, and Newfoundland—they were rather more than a third of the total imports, but still only worth £2 per head of the population in those colonies. Broadly, the result appears to come to this, that the colonies in which the population is mainly derived by birth or by descent from this country and from Europe, take a larger proportion of British goods than those colonies in which an indigenous or a coloured population prevails.

That this should be the case is probable enough. The British immigrant into New Zealand or South Australia is not only a far more vigorous being than the average inhabitants of Jamaica or Tobago, but he lives in a climate where British goods will be of more service to him; and besides he preserves a preference for the articles made in the country which he still calls home. Still, making every allowance for that influence, it is a very curious fact that the average inhabitant of the Australian group of colonies consumes about £9 a year of British produce, while the corresponding dweller in the Canadian group takes little more than £2—roughly speaking, only one-quarter of the other.

Much must be put down to the exportations of gold from the Australian group; something also to the comparatively recent occupation of the territory, which may not have allowed time for some manufactures to develop themselves fully, though they have commenced a vigorous existence; something, perhaps, to greater

wealth, to a climate in some respects more productive, and allowing more margin for the import of luxuries, the main energy of the inhabitants not being directed to a mere struggle for life; something also to differences in the tariffs. But even after making every allowance for these influences, the recorded results are remarkable. The greater distance from Great Britain to the Antipodes, when compared with the short passage to North America, may just be mentioned as an influence which weighs in the opposite scale to those just mentioned. But mere proximity to Great Britain is, as has been shown, not sufficient to produce a considerable export of itself. As far as proximity is concerned, we have to meet, in trading with our North American colonies, a rival not only nearer in distance, but one understanding the circumstances of the business better, and further, more willing and able to adjust what it supplies to the wants of the case.

A recent report from the secretaries of Embassy and Legation contains a review by Mr. Drummond of the foreign commerce of the United States. This report, though it commemorates the adulterations which, in too many instances, American manufacturers have introduced into their goods, states again, with great clearness, what everyone conversant with the industries of the United States knows, the extreme pains American manufacturers take to adjust their wares to the immediate wants of those who use them. Scarcity and dearness of labour has led to the introduction of labour-saving machinery, which has, among other advantages over hand-labour, this one—that a machine-made article may be relied on to be exactly true to the pattern. Little points, as they seem, in lightness and finish, have a great influence on the purchaser. Even in cutlery, it would appear that the American manufacturer is not only getting the trade in America into his own hands, but exporting to other countries. The building of tramway cars, a most recent manufacture, seems also one in which America can well compete with us. The similarity of requirement in the two countries—the United States and British North America—gives American manufacturers in some respects the advantage over us. What people actually use they are the better able to improve and to carry to perfection. But these circumstances should be to our manufacturers but the greater incentives to exertion. It is not by reposing on what we have done that we can make progress; it is only by adapting our goods to the wants of those who will not otherwise remain our customers. Though the contrast between the exports to Australia and North America is striking, it is slight indeed when compared with the value per head of the exports to British India. Here there is probably less possibility of an increase, but even here attention to the wants of the native, and the supply of a trustworthy article, will do more for British trade than anything which can be proposed. As the prosperity of that country increases, our exports, if we take the pains to send what is really wanted, will surely enlarge also.

GREENWICH OBSERVATORY.

The Astronomer-Royal, in his last report to the Board of Visitors (June 7, 1879), notices in regard to the Greenwich time-ball that there has been only one failure from accident in the automatic drop; on six days the ball was not raised on account of high wind; and on one day the mast was so thickly coated with ice that the ball could not be moved. The Deal ball was not dropped at one o'clock on seven days, through failure in the telegraphic connexion; on two days the ball was accidentally dropped about two secs. too soon by telegraph signals; on 17 days the current was weak, and the trigger was released by the attendant, without appreciable loss of accuracy; on the nine days of failure of the ball-drop at one o'clock, a black flag was hoisted, and the ball was dropped again at two o'clock. The Westminster clock has not been quite so well regulated as usual. During the period to which this report refers, its error exceeded one sec. on 77 days; on 15 of these it was between two secs. and three secs., on four between three secs. and four secs., and on one day it exceeded four secs.

In his general remarks Sir George Airy reports that the question of the advisability of reducing the extent of the annual volume of "Greenwich Observations" is still under consideration, and he concludes with the following observation:—"The general tendency is to increase the annual expenses of the Observatory. And so it has been, almost continually, for the last 42 years. The annual ordinary expenses are now between two and a half and three times as great as in my first years at the Royal Observatory. I would fain flatter myself that the value of its results has increased in a greater degree."

SILK-PRODUCING BOMBYCES.

Mr. Alfred Wailly has communicated some notes to the *Entomologist* on the reproduction of certain silk-producing bombyces in a state of confinement, which bear upon his communication printed in the *Journal* for June 6th last (p. 362):—

The two species—*Attacus Pernyi* and *Samia Cynthia*—pair very readily; but with most other species pairing is the exception rather than the rule. Why should *Pernyi* and *Cynthia* pair very readily in any situation, and most other species only accidentally? In a state of nature certain species are reproduced to a far greater extent than others. When in a state of confinement the moths of exotic or even native species suffer from several causes—want of room, air, moisture, &c. With respect to native species, the cages containing the moths may be placed in the open air, and moisture may be supplied by watering the cages or placing wet sponges in them; but exotic species, if treated in the same manner, may have to suffer from another cause—the climatic difference between their native country and that of England, or any other northern country.

Hence the difficulty of obtaining fertile eggs, especially of exotic species, even supposing that male and female moths emerge simultaneously, which is not often the case unless a large number of pupæ be kept. In the middle of July I had at one time twelve fresh Atlas moths, male and female, three of which were of the giant race, yet I could not obtain a single pairing. Previously I had obtained a pairing with two of the smaller species of Atlas. With about fifty cocoons of *Pyri*, I only obtained three or four pairings.

Some persons think that if they have a few pupæ of one species they are certain to obtain fertile eggs. This is a great mistake, although the thing is not impossible. Now, with respect to the time and duration of the pairing of the species mentioned in my notes, *Promethea* moths I found to pair in the afternoon, or early in the evening; most other species, very much later. The pairing of *Yama-Maï* and *Promethea* is very short; that of *Pernyi* and *Cynthia* is of very long duration; that of *Cecropia* is long also. The pairing of *Polyphemus* with some moths is very short; with others, it lasts from about 10 or 11 o'clock in the evening till next morning. The pairing of my Atlas moths lasted from about 10 or 11 o'clock in the evening till seven o'clock p.m. of the following day. Of four pairings of *Actias Selene* two were of short duration, from about two o'clock in the morning till about five (three hours); the last two from the same time till about seven p.m. the following day. The average quantity of fertile eggs obtained from the four pairings was about the same from each female, the duration of the pairing having had no effect, that I could detect, upon the quality or quantity of fertile

eggs; and it was the same with respect to the fertile eggs obtained from *Polyphemus*.

I have kept about forty pupæ of *Endromis versicolora*, with the object of obtaining fertile eggs. Only twenty moths emerged—seventeen males and three females. The first two females did not pair; the third female did pair for a considerable time, but died without laying a single egg. *E. versicolora* moths emerged from the beginning of March till the 5th of April.

Moths of *Attacus Roylei* all emerged from the 5th till the 20th of June; seven males made their appearance first. Subsequently I obtained seven fine females, which I placed with equally fine males in seven separate cages; but I regret to say I could not observe any of the couples *in coitu*. *A. Roylei* is a very wild species, resembling in shape and habits *B. Yama-Maï*. The eggs are similar, but somewhat larger than those of *B. Pernyi*.

From the fact of my having been unable to detect any pairing of *A. Roylei*, it does not follow that the eggs I have obtained will be sterile, the pairing taking place sometimes very early in the morning, as is the case with *Actias Selene*, and lasting but a very short time. I may, therefore, yet hope that many of the eggs will be fertile.

Of *Caligula Simla* I have just received twenty-four eggs, but only three larvæ have as yet hatched; these refused to eat chestnut and oak, and have died. The other eggs, which seem in good condition, will very likely hatch; if so, I intend trying other food-plants.

The long and severe winter we have had seems to have affected my pupæ of the different species of Lepidoptera, and has delayed the emergence of the moths for several weeks. In all probability it has caused the death of many of the early spring species, such as *Endromis versicolora*, *Aglia Tau*, *Attacus Spini*, and others.

GENERAL NOTES.

Bessemer Steel.—Before the adoption of the Bessemer process in the production of steel the entire production of cast steel in Great Britain was only about 50,000 tons annually, and its average price, which ranged from £50 to £60 per ton, was prohibitory of its use for many of the purposes to which it is now universally applied. In the year 1877, notwithstanding the depression of trade, the Bessemer steel produced in Great Britain alone amounted to 750,600 tons, or fifteen times the total of the former method of manufacture; while the selling price averaged only £10 per ton, and the coal consumed in producing it was less by 3,500,000 tons than would have been required in order to make the same quantity of steel by the old or Sheffield process. The total reduction of cost is equal to about £30,000,000 sterling upon the quantity manufactured in England during the year; and in this way steel has been rendered available for a vast number of purpose in which its qualities are of the greatest possible value, but from which its high price formerly excluded it. During the same year the Bessemer steel manufactured in the five other countries in which the business is chiefly conducted—namely, the United States, Belgium, Germany, France, and Sweden—raised the total output to 1,874,278 tons, with a net selling value of about £20,000,000 sterling. The works in which these operations were carried on were eighty-four in number, and represent a capital of more than three millions. According to the calculations of Mr. Price Williams, who has made the endurance of rails a matter of careful study, the substitution of Bessemer steel for iron for this purpose alone will produce a saving of expenditure during the life of one set of steel rails on all the existing lines in Great Britain of a sum of more than one hundred and seventy millions sterling. It may safely be said that there is no other instance in history of an analogous impetus to manufacture, or of an analogous economy, being the result of the brain-work of a single individual; still less is there an instance of such results being realised while the inventor was living to enjoy the fruits of his labours, and able to work in fresh directions to increase the benefits which he had already conferred upon his country and upon mankind.—*Times*.

Incombustible Wood.—M. M. P. Folbarri claims that he has discovered a method by which wood of any kind can be rendered incombustible. The following chemical compound is said to produce the result:—Sulphate of zinc, 55 lb.; American potash, 22 lb.; American alum, 44 lb.; oxide of manganese, 22 lb.; sulphuric acid of 60°, 22 lb.; water, 55 lb.; all of the solids are to be poured into an iron boiler containing the water at a temperature of 45° C., or 113° F. As soon as the substances are dissolved, the sulphuric acid is to be poured in little by little, until all the substances are completely saturated. For the preparation of the wood, it should be placed in a suitable apparatus, and arranged in various sizes (according to the purposes for which it is intended) on iron gratings, care being taken that there is a space of about half an inch between every two pieces of wood. The chemical compound is then pumped into the apparatus, and as soon as the vacant spaces are filled up it is boiled for three hours. The wood is then taken out and laid on a wooden grating in the open air, to be rendered solid, after which it is fit for uses of all kinds, as ship-building, house-building, railway carriages and trucks, fence-posts, wood paving—in short for any kind of work where there is any liability to destruction by fire.—*Building News*.

Australian Gold Coinage.—The Deputy Master of the Mint gives in his report a return of the gross weight of the gold received for coinage at the Sydney branch of the Royal Mint, from the opening of the Mint in 1855 to the end of 1878, which amounted to 11,546,463·95 ounces. This gold was produced by the various colonies in the following proportions:—

	Ounces.
New South Wales	6,083,390·29
Queensland	2,238,937·98
New Zealand	1,767,943·73
Victoria	1,437,657·61
Tasmania	5,719·66
South Australia	1,729·92
New Caledonia	8,344·02
Other Countries	2,740·74
	11,546,463·95

NOTICES.

GROSVENOR HOUSE.

The Duke of Westminster is desirous that designers, artisans, and the like, employed in any branch of Art applied to productive industry, should have the opportunity of inspecting Grosvenor House, with its Works of Art, daily, including Sundays, during the months of August and September, 1879, from 2 p.m. to 6 p.m. He regrets that, for want of room, he cannot extend the admission beyond the persons specified.

A number of tickets of admission have been placed in the hands of the Secretary of the Society, for distribution among persons answering to the above description.

Such persons can obtain tickets on application at the Society's house, by bringing with them a paper containing their names, addresses, and occupations.

Each ticket admits a party of four.

There will be no admission on wet afternoons.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

NATIONAL WATER SUPPLY, SEWAGE AND HEALTH.

The report of the Conference held in May last is now ready, and can be obtained at the Society's House, price 1s. 6d. paper, 2s. boards with cloth back.

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CANTOR LECTURES.

DWELLING-HOUSES: THEIR SANITARY CONSTRUCTION AND ARRANGEMENTS.

By Prof. W. H. Corfield, M.A. M.D. (Oxon).

Lecture IV.—Delivered March 10.

Removal of Refuse Matters.

Dust. Kitchen Refuse, Earth-closets, &c. Conservancy and Water-carriage Systems Compared.

A very important matter in the sanitary administration of large towns, and an important matter for the consideration of every householder, is the regular and frequent removal of house refuse known as "dust." This consists chiefly of ashes and cinders; but, unfortunately, the dust-bin or ash-pit is only too convenient a receptacle for all kinds of refuse matters, including kitchen *débris*, and so, in a large number of instances, these receptacles, especially in hot weather, become excessively foul, and an abominable nuisance. If the dust were removed daily, as it should be wherever this is practicable, the mixture of organic matter with it would not be of great importance, but where this cannot be done, it is very necessary to insist that the dust-bin shall be used for nothing but ashes, and that all organic kitchen refuse, such as cabbage leaves and stalks, shall be burnt. This can be done without any nuisance by piling them on the remains of the kitchen fire the last thing at night; thus they are gradually dried during the night, and help to light the fire in the morning. When dust is valuable to those who contract to remove it (for this work is generally let out to contractors by the parish authorities, although in several instances it is now being done with great advantage and saving to the ratepayers by the parish workmen themselves), there is no difficulty in getting it removed. The contractors are only too glad to get it, and even prosecute people who keep any of it back for their own uses. The cinders and ashes from dust-bins are largely used in brickmaking, and so when the building trade is slack dust becomes worthless. The contractors, instead of paying for it, require to be paid considerable sums to take it away, and the less they take away, and the less frequently they call for it, the more advantage do they get out of their bargains. This has been the case for some years, and in one parish alone, that of Islington, where I was formerly Medical Officer of Health, the difference that it made to the sanitary authority in one year as compared with another only six years before, was no less than £6,257; whereas in the former year the sanitary authority received £2,200 from the contractors, in the latter they had to pay £4,057. No doubt, the best plan to get rid of such refuse matters would be to put them outside the door early in the morning in a box or bucket, to be called for every morning by the contractor's men, and this is already done in some places. Otherwise it is necessary for every householder to take care that his dust-bin does not become a nuisance to himself or his neighbours, from too large an accumulation being allowed to remain in it, or from improper matters being thrown into it. Dust receptacles ought not to be kept inside houses, as they very frequently are. Neither ought they to be built against the wall of the house, unless cased with an impervious layer of cement, to prevent emanations from them percolating through the walls into the interior of the house. They ought always to be covered with a sloping roof, so that the rain may run off; if rain water is allowed to get into them, they are much more likely to become a nuisance. Rain-water pipes ought not to be carried through dust-bins, or foul air from the latter will get into the pipe through a leaky joint, or a damaged place, and ascend it, causing a nuisance in one of the upper rooms, or elsewhere. I have known a serious nuisance caused in this way.

Removal of Excretal Matters by Conservancy Systems.

Under these systems the excretal matters are either collected without any admixture, in receptacles known as cesspools, or they are mixed with ashes, and the other house refuse, forming what is called a "midden heap," and of these two old plans all the dry closets, pail, and tub systems, &c., may be said to be modifications. Cesspools were formerly largely used, especially for houses built on porous soils. A pit was dug into which the excretal matters were discharged and allowed to percolate away into the soil—frequently into neighbouring wells. Often there was not only no pretence at making this pit impervious, but every facility was given to allow of the percolation of the foul water, &c., into the soil around. Thus the walls (when there were any) were made merely of rough blocks of stone placed one upon another. In some instances, these pits were not opened for many years together. Such cesspools were constructed long before water-closets came into use, and were often retained after the introduction of these. In many instances they are placed underneath houses, and under the basements of large houses there are sometimes several of them. They form a serious nuisance, lasting for many years, as foul air from them finds its way into the house, even when there are no waste pipes directly connected with them, as there generally are, and thus they are very dangerous to health, even supposing that they are so placed as not to contaminate the water supply. In some towns, it was, positively, formerly a practice to dig them down until a spring, or water of some kind, was reached, in order that they might not require to be emptied. In all old houses, it is imperative to search diligently even for unused cesspools, and to trace the course of every pipe from every part of the house. In many instances, openings from the basement floor lead into disused cesspools, even in houses that have been drained, and the cesspools presumably abolished. A basement drain is not unfrequently allowed to discharge into an old cesspool, after a properly constructed sewer has been made to receive the refuse matters from the water-closets. This is a source of great danger to the inmates of the house.

In some instances, however, cesspools are made of brickwork set in cement and lined internally with a layer of cement, so as to be impervious to water. They then require to be emptied periodically, a process which often causes a considerable nuisance, and they require, moreover, to be at a considerable distance from the house, and to be disconnected from the house drains and sewers in a manner that will be described in the next lecture. Not unfrequently, however, they are placed directly underneath the house or under the court-yard, as is commonly the practice in Paris and many other continental cities and towns. Pipes are laid straight into them from the various storeys of the house, and sometimes these are the only ventilating pipes through which foul air can escape. Occasionally they are made to overflow into sewers or drains, and sometimes a kind of strainer is placed inside them, so that the solid refuse may be collected, and the liquids allowed to escape into a sewer or drain. They used formerly to be emptied by hand and bucket, thereby causing an abominable nuisance, and the workmen employed for this purpose were frequently suffocated by the foul air, and suffered from inflammation of the eyes caused by the ammoniacal vapours. Of late years, they have been emptied by hose into air-tight carts, from which the air has been previously exhausted by a powerful pump. This process, of course, causes less nuisance, and is not dangerous to the men employed, but, even with these improvements, the system is a very disagreeable one.

In some towns, large midden heaps are still in vogue. The mixture of ashes and other house refuse with the excretal matters produces a drier mass, which, if not exposed to the rain, is considered to cause less nuisance than cesspools; but if dust-bins are bad and are nuisances, as they most certainly are in a very large number of instances, midden heaps must be very much worse. Refuse matters become nuisances and injurious to health when they are allowed to remain in the vicinity of habitations. In all towns where refuse matters are not removed immediately there is a high death-rate, and especially a high children's death-rate, and in all towns (as Dr. Buchanan has shown in the ninth report of the Medical Officer of the Privy Council) where refuse matters are removed more speedily than they were formerly, the general death-rate has been lessened. The improvements that have been made, then, in these conservancy systems, consist in diminishing in various ways the size of the receptacles, so that the refuse matters cannot be collected in so large an amount, or kept for so long in and near the house, and in making receptacles impervious to water, so that liquids cannot escape from them into the soil around, nor water get into them. Sometimes the receptacles are drained into the sewers, so that the liquid part can run away, leaving the contents of the receptacle drier. In other cases they are not. The improvements in cesspools, then, have consisted in making them smaller and smaller, and, lastly, moveable—the *fosses mobiles* of the Continent; the pans, pails, tubs, &c., of some of our large towns. These movable receptacles are placed underneath the seats of the closets, fetched away when full by the scavenger, and replaced by the empty ones. They are, or ought to be, fitted with air-tight lids, so that as little nuisance as possible may be caused by carrying them to the carts; but, as may be expected, in many instances they are allowed to get too full, and a great nuisance is often caused in the houses. Nevertheless, this plan is a considerable improvement upon the plan of large buried cesspools. One of these pails that is largely in use is Haresceugh's spring-lid receptacle, a specimen of which may be seen in the Parkes Museum.

Similar improvements have been made in middens. The pits, in which the excretal matter and ashes are collected, have been made smaller and smaller, and impervious to water, until, at last, in some towns, they are above the ground, and consist only of the space beneath the seat of the closet made into an impervious receptacle, and usually drained into a sewer or drain. This, of

course, necessitates their being emptied frequently, which is done by hand and spade labour. A capital plan is that adopted by Dr. Bayliss, the Medical Officer of Health for the West Kent Combined Districts, in which there is a ventilating shaft from the back part of the receptacle, rising above the roof of the closet. This allows the foul air to escape above the roof, while fresh air enters through openings cut in the door. Sometimes boxes or pails are used and removed periodically, as in the case of the tubs and pails, previously described as moveable cesspools, the only difference being that ashes, &c., are thrown in with a scoop, or by means of some self-acting apparatus. A contrivance which is now largely used, in towns where this system is in vogue, is Morell's cinder-sifting ash-closet, of which I have a model here. (A full-sized specimen may be seen in the Parkes Museum.) The ashes are thrown on to the sifter, through the interstices of which the fine ash passes into a hopper, and the cinders fall off and may be collected and used again. The hopper is connected with the seat in such a manner that the weight of the person moves the seat a little, and jerks some of the fine ash down into the lower part of the hopper, from which it is thrown into the midden by another jerk when the person rises. Another contrivance of this kind is Moser's, which is also of very simple construction, and others are Taylor's and Weir's. The Eureka and Goux, and some other systems are varieties of the pail system in which an absorbent of some kind or another is used.

We now come to a consideration of the dry-earth system, which was brought into prominence by the Rev. Henry Moule. It consists in throwing over the excretal matters a certain quantity of dried and sifted earth, when an absorption takes place, and a compost is produced which is perfectly inoffensive to the sense of smell. The earth may be dried and used over and over again for five or six times, or even more, and any earth except chalk or sand will answer the purpose. It may be thrown by hand, or by a self-acting apparatus moved by the weight of the person, or by the door of the closet, or by a pull-up apparatus similar to that ordinarily used in water-closets. It will be seen at once that with this system there is not only something to be taken away, but something to be brought into the towns and into the houses—the dried earth; and this constitutes a very serious objection. However, it is an objection that might perhaps be waived, if the system could be satisfactorily worked on a large scale and by careless persons, for it is essential, in a large town at any rate, that a system for the removal of refuse matters must be used which can be worked by the most careless persons. When we consider that, if the supply of earth were to fail for a day, a serious nuisance would be caused in every house; that if a servant throws a pail of slops into an earth-closet it becomes a cesspool; that the apparatus may get out of order, so that earth is not thrown in even though the hopper be full; and that an enormous quantity of earth would be required in every large town, we shall see that, at any rate for large towns, it is impracticable; and when added to this, we find the fact that one great argument in favour of the system, the supposed value of the manure produced, is entirely fallacious, it having been shown by the Sewage Committee of the British Association, that the compost, even after passing six times through the closets, can only be regarded as a rich garden soil, and would not pay the cost of carriage even to a small distance; that, in fact, in the disintegration and decomposition of the organic matters that takes place in the mass, almost all the nitrogen is got rid of in some way or another, we see that one great argument for its use in towns disappears. We must remember, too, that deodorisation is not necessarily disinfection, and, as Dr. Parkes pointed out, we do not know that the poisons—say of typhoid fever and cholera—are destroyed by being mixed with dried earth. It is even possible that they are preserved by it, and there can be no doubt that if the earth is not sufficiently dried, or if water is thrown on the mass, considerable danger would arise if the poisons of such diseases were present. While, however, the system is impracticable for large communities, it is one that has been found very useful indeed under suitable circumstances. It is useful for temporary large gatherings of people at flower shows, cattle shows, race meetings, volunteer reviews, &c., especially where there is strict supervision, and where persons can be told off to attend to the distribution of the earth. Earth-closets are suitable for use in villages and country houses in the open air, but they ought not, in my opinion, to be placed indoors even in the country. Where the earth can be collected and dried on the spot, and the compost afterwards used upon the garden, the plan has been found very useful if only sufficient care be exercised, and no nuisance need be produced.

To sum up with regard to the conservancy plans, their very name condemns them one and all, for use in large towns at any rate, or in the interior of houses. One of the most important of sanitary principles is, that the refuse matters should be removed as speedily and as continuously as possible from the neighbourhood of habitations, and the principle of all conservancy systems is that the refuse matters are to be kept in and about the house, at any rate, as long as they are not a nuisance, which of course means that, in a large number of cases, they become a serious nuisance. It is also obvious that the carriage of the refuse matters entails considerable cost under any of these systems, and so the less frequently they are removed the less does it cost, and what is detrimental to the life of the population becomes advantageous to the ratepayers. If the manure so collected were valuable, it might, of course, be made to pay the cost of collecting, but this is not the case as a rule, the only instance in which any of these systems have been made to pay being where the excretal matters have been collected in pails or tubs, unmixed with anything which would lessen their value. With all these systems, too, it is necessary to have some method for disposing of the slops and foul water generally, which cannot be allowed to run into the water-courses, as it would contaminate them, and so it is necessary to have sewers, the construction of which will be described in the next lecture.

As opposed to the conservancy systems, we have the water-carriage system, by means of which the refuse excretal matters are conveyed away in the foul water by gravitation through the sewers, and

are thus removed from the houses as speedily and cheaply as possible by means of the pipes, which must in any case be provided in towns, to get rid of the foul water. The sewage is increased in bulk, but is not rendered perceptibly fouler by this admixture. Indeed, as a rule, the sewage of a town supplied with water-closets is less foul than that of a town supplied with middens. Although, however, sewers are necessary in towns to carry the foul water away, in country places the slop water may be allowed to run into the surface drains, provided they do not pass near wells, and this is best managed by means of a contrivance which I shall exhibit in another lecture.

The water-carriage system has disadvantages of its own, and requires special precautions to be taken, which, so far as they are connected with dwelling-houses, will be described in the next two lectures.

NATIONAL WATER SUPPLY.

THE WATER SUPPLY OF RURAL DISTRICTS.

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By the amended Sanitary Act of last Session, which came into existence a few months since, it has become the duty of the Rural Sanitary Authorities of this country to secure to every cottage and house a supply of wholesome water, provided that such water can be supplied at a reasonable cost. The maximum fixed by the Act is a sum which shall not entail a greater weekly charge than 2d. for each house, allowing interest at the rate of 5 per cent. This represents a capital outlay of £8 13s. 4d.

In rural districts, where the houses are scattered, an organised system of supply from one general source, such as prevails in towns, is often impracticable at any reasonable cost, and, even where practicable for the supply of houses aggregated in a village, the unfairness of taxing a whole parish for one particular portion, and calling upon persons to contribute towards works from which they derive no benefit, is so inequitable as to make such detached local supplies often impolitic if other means can be provided. It is the purpose of this paper to show that it is quite possible to supply every cottage and house in the rural districts of this country, however isolated, with a sufficient quantity of wholesome water, at a cost not exceeding the limit laid down in the Act, and also, by examples of works already executed, to direct attention to the simplest and most effective way of carrying out, not only the provisions of this Act for the supply of water for domestic use, but also for agricultural purposes generally.

Quantity Required.

The minimum quantity that is sufficient for the supply of a cottage or small farm-house, for all ordinary domestic purposes, may be taken at $13\frac{3}{4}$ gallons per day, allowing $5\frac{1}{2}$ persons as the average number to a house, and $2\frac{1}{2}$ gallons for each person. This, of course, gives no margin for water-closets, baths, or other similar luxuries, which belong only to a larger class of dwelling. This quantity may appear small; but, having made extensive inquiries amongst cottagers and others, I found sufficient evidence to satisfy myself that it was the full quantity that was used when the water had to be baled or pumped from a tank, and not left to run to waste from a tap. Mr. Easton, the eminent water engineer, in his evidence before the Select Committee on the Public Health Act Amendment of 1878, stated that, as the result of his experience and inquiries amongst cottages in Sussex, he was satisfied that this quantity was sufficient. Col. Cox put the quantity at three gallons a day, and the other witnesses agreed with the estimates of Mr. Easton and Col. Cox, some even putting it at less. In the sixth report of the Rivers Pollution Commissioners is given an instance of four cottages provided with a tank, in which the rain water was collected from the roofs, one of the inhabitants being a laundress, who used a large quantity of water, and another feeding a number of pigs. The size of this tank was barely sufficient to give 10 gallons a day to each cottage, yet it is stated that it had never failed to maintain a sufficient supply.

The large quantity used in towns, varying from 20 to 30 gallons a head, is due partly to manufactories, street watering, and flushing sewers, but principally to waste. This is proved by the fact that towns supplied by meter do not average more than seven gallons a head, and by the test applied to several streets in Brighton, where it was found that the supply did not average more than $4\frac{2}{3}$ gallons a head, although the number of persons to a house would be above the average, and water-closets and baths be freely used.

Rain Water Supply.

The simplest means of supply is by collecting the rain as it falls from the heavens, and storing it in tanks.

The doubt which was for a time cast upon the wholesomeness of this source of supply by the Rivers Pollution Commissioners, by the statement in their sixth report, that rain "is in reality water which has washed a more or less dirty atmosphere, and is laden with mineral and excrementitious dust, zymotic germs, and the products of animal and vegetable decay and putrefaction" has, I think, been now sufficiently dispelled, and the above statement considered to be only a fanciful effort of imagination, in which not one of the scientific witnesses examined by the Select Committee of last year agreed. Mr. Rawlinson, in reply to a question on the subject, said that "he did not believe one word of it," and that "if only one-tenth part of what is said about water happened to be true, his only surprise was that a human being lived on the face of the earth." Certainly, as far as the Fen districts, with which I have an intimate knowledge, are concerned, if rain water contains the zymotic germs and other impurities mentioned above, these must be much more wholesome drink than they are generally supposed to be, for there scarcely any other water is used.

With regard to the impurity of rain water, Dr. Ballard remarked, in his evidence before the same committee, that although some simple system of filtration might be desirable, he did not consider any enactment on the subject necessary, as in country districts the only chance of pollution

of rain water from the roofs would be the excrement of birds and dead leaves blown in the gutter, and that the amount of this would be so trifling as not to produce any mischief; with this Mr. Easton agreed. Sir Harcourt Johnson also stated that in Yorkshire he had employed rain water tanks, with great success, for the supply of the cottages, and in no instance had there been a failure of a tank; that he had drunk the water out of these cemented tanks, and found it exceedingly good, and in summer remarkably cool. Mr. Clutton also spoke as to the general and satisfactory use of tanks for the cottages on the estates for which his firm acted. Soot from the chimneys is by some persons added to the list of impurities, but although this may give the peculiarly flat taste which unfiltered rain water has, yet, being nothing but carbon, it may fairly be considered as a purifying agent, to rectify any harm that may be likely to arise from the leaves and excrement. Simple filtration through charcoal and sand, immediately before use, entirely removes this flat taste, and makes the water bright and sparkling. If the filter be so constructed that the charcoal, when not actually filtering the water, is exposed to the air, it will remain serviceable for a considerable time. To keep the water sweet, provision should always be made for the admission of air into the tank in which it is stored, but, to prevent the growth of vegetation, it is necessary to exclude the light.

Granting that $2\frac{1}{2}$ gallons per head is enough for all the ordinary domestic requirements of a cottage, sufficient rain falls on the roof of every house in the course of a year, if properly stored, to yield a full supply.

A cottage with its outbuildings covers about 500 square feet of ground. Taking the rainfall at 22 inches per annum, the quantity that may be relied on as an average in the driest districts of the country, a slated roof will yield 5,700 gallons, equal to a daily supply of $15\frac{1}{2}$ gallons, or rather more than $2\frac{3}{4}$ gallons per head. Tiled roofs would yield less than this, being more porous than slates. Thatched roofs may be considered as altogether unsuitable for the collection of rain water, from their absorbent nature, the difficulty of providing spouting, and the chance of pollution from the organic matter in the decaying straw.

The rainfall being distributed over the whole of the year, the storage tank is constantly being replenished. With rainfall collected from land, large provision has to be made for periods of drought and for the decrease in the supply during the summer months, owing to the great amount of evaporation from the dried-up surface of the ground, and the water absorbed by the growing vegetation. With the supply from roofs, the circumstances are different. On an average of years, the heaviest rainfalls will be found to occur during the summer months from thunder-storms, nearly the whole of which will be stored. Having carefully calculated the daily demand, as against the supply from the rainfall, for the east of England, I found that the tanks ought to be large enough to hold 78 days supply, and having constructed a great number based on this calculation, experience has proved its correctness.

Assuming the available rainfall to be 22 inches, and allowing for storage for 78 days' supply, the proportion of tank room to roof should be $2\frac{1}{2}$ gallons for every square foot of ground covered for cottages, or rather less for farmsteads and large buildings. Thus, a tank for a cottage covering 500 square feet would require to be 6 ft. 6 in. in diameter and 6 ft. deep up to the springing of the dome, and hold 1,200 gallons; but, in all cases, it is better to allow a greater capacity than is actually required, to prevent the pipe from the pump going too near the bottom, or the settlement being stirred up by the bucket or bailer. The best form for small tanks is circular, as being the strongest, and giving the greatest capacity for its outline, and, therefore, cheapest. For larger tanks, the form should be oblong, with circular ends, or, at least, the interior angles filled up. The ordinary method of construction is with brickwork, rendered with a coating of cement inside, domed over, and finished with a stone and iron lid let into a rebate, the water being obtained by a small iron bucket fastened on the end of a pole. For cottages, this is simpler and less expensive than a pump—which frequently requires repairs—and is less wasteful of the water. When the soil is porous, the tank may require puddling round with clay. When bricks are not easily procurable, or when several tanks have to be made, concrete, mixed with Portland cement, forms a better and more trustworthy material than brickwork. Mr. Clutton informed the Committee of last Session that he was now using concrete for all the cottages built on the estates under his management.

Taking the ordinary average price of materials and labour in the country—and there is not any great difference now between one place and another—a brick tank, properly cemented, domed over, and finished with manhole and cover, may be estimated to cost at the rate of $1\frac{1}{4}$d. per gallon. Larger tanks may be reckoned at 1d. per gallon, and hence there is economy in making one tank for the supply of two, or even three cottages. At this rate, the cost of the water supply for an ordinary cottage would be £6 5s., well within the limit laid down by the Sanitary Act.

Churches and schools might be made valuable aids in supplementing a village supply. The tanks for receiving this would not necessarily be constructed in the churchyard, but could be placed near to a group of houses, the water being conveyed to it from the roof spouts by iron pipes. An ordinary village church covers about 7,000 square feet, and the schools 1,000 more; these together would yield over 90,000 gallons a-year, sufficient for 16 cottages.

The Baroness Burdett Coutts has, in a village on her property in Wiltshire, had a tank constructed to take the water from the church, and it was found that as many as 120 buckets of water were counted as being fetched in one day—the villagers esteeming the work as one of the greatest acts of kindness that could have been done for them.

Supplies for Agricultural Purposes.

Beyond the ordinary requirements for domestic use, farmsteads require a considerable quantity of water for the stock in the yards, for threshing and other purposes, but the roofs of the cattle sheds, barns, stables, and other buildings, are capacious enough to collect a sufficient supply. It is very rarely that new buildings are erected without proper provision being made for collecting the

water from the roofs, and on all well-managed estates the old buildings are now spouted. Formerly, no doubt, it was the practice to allow all the rain to drip from the roofs on to the ground, not only to the detriment of the brick walls, but also soaking the ground, and making the yards wet and cold; thus, while the available supply was wasted, in summer water had to be fetched in carts for the stock from a very considerable distance, an instance being given of a case in the east of England when there was no fresh water available within 15 miles.

Taking a typical case of a homestead for a farm of 100 acres of mixed land, the minimum requirements would be about 30 gallons a day for the house, 50 gallons for the stables and cow-sheds, &c., together 29,200 gallons in a year. To this must be added about 20,000 gallons more for threshing, and watering the stock in winter, or a total of 49,200 gallons. The roof of the farmhouse would cover about 1,000 square feet, and with 22 inches of rainfall yield 11,419 gallons, or a little more than 31 gallons a day. The farm buildings and sheds would cover about 3,500 square feet, and collect 30,965 gallons, equal to a supply of 110 gallons a day.

The supply for stock in the fields during the summer months is equally a matter deserving consideration. On the high lands on the Oolite or other absorbent formations, when laid down as permanent pasture, or if arable land, during the time they are in seeds, water must be provided for the sheep and cattle to drink. This is generally done by sinking deep wells and pumping the water up, or by carting it. A little calculation would show that it would be far more economical to gather and store the rainfall in brick tanks.

On the downs and high chalk lands provision is often made by constructing what have hitherto been termed "dew ponds," from an idea that they collected the dew, but really these ponds are nothing more than collecting grounds and receiving tanks. They are made with exceedingly flat slopes, terminating in an almost conical bottom, are puddled with clay and chopped straw, and thus made impervious to the rain, which, falling on the sides, is collected in the bottom, the summer showers yielding a quantity sufficient to replace the loss by evaporation, leaving the winter store for use. In one of these ponds in Berkshire, where observations were made by Mr. Slade, C.E., and published in a very interesting pamphlet, it was found that taking the period from the beginning of June to the end of September, a fall of $11\frac{3}{4}$ inches of rain on the surface of the pond, $69\frac{1}{2}$ feet in diameter, yielded 23,043 gallons, which, as nearly as possible, balanced the quantity lost by evaporation; the supply for drinking of the sheep, which only amounted to 6,203 gallons, being obtained from the rain stored during the winter. A very wasteful way for providing and storing water. The cost of constructing the pond was £40. A brick tank of sufficient capacity to yield a similar supply would only have cost £12. A collecting ground $26\frac{1}{2}$ feet in diameter, made in a dished form, and covered either with cement, concrete, or asphalte made with tar and gravel, would cost from £3 to £5 more, and yield sufficient rainfall to fill the tank. Thus, while the cost would only be three-eighths that of the pond, the area of the ground occupied would be about one-sixth. If the collecting ground assumed the form of a shed, which would also answer the purpose of sheltering the stock from the sun, the total cost of shed and tank would not be more than that of the pond.

A tank placed in a corner where four fields meet, would serve not only for drinking purposes, but also for supplying the engine during the process of steam cultivation. The constantly increasing use of steam power in cultivating the land renders a ready supply of water a necessity to the economical working of this agent. Every acre of land that is cultivated by steam requires from 100 to 125 gallons of water, in addition to that used for driving the thrashing machine, which may be put at from 50 to 60 gallons per acre. Hence, a further necessity of storing water and providing reservoirs readily accessible to the fields requiring cultivation. On impermeable soils storage, can be accomplished, by sinking ordinary ponds, at considerably less expense than making tanks. Messrs. Howard, the well-known makers of cultivating machinery, have on their farm in Bedfordshire so designed the drainage that it supplies a tank or pond at every site occupied by the engine during the tillage of the whole of the estate, and at the homestead a reservoir has been excavated in the clay which holds half a million gallons of water.

In districts where water is plentiful, the supply for agricultural purposes may probably be more advantageously distributed by a system of pipes covering the whole country. Sir Harcourt Johnstone, in his evidence before the Committee, stated that on the estates with which he was concerned in Yorkshire, on some of the large farms the water was raised by rams, and conveyed to every single pasture field, and the water itself carried into the houses, and laid on in the back kitchen of every cottage of a whole parish. On one farm, the rental of which was £380 a year, the water was laid on to the farm premises, and to every pasture field, with troughs and ball cocks, at an expense of £336, the farmer considering it such a boon to him to have the water at all times in the summer without the necessity of conveying it by means of horses and carts, and barrels, that he willingly paid five per cent. on the outlay in addition to the rent of the farm. On another estate, £480 was expended in putting down a ram and laying two miles of pipes communicating with the yards, houses, cottages, and pasture fields, on every farm.

Supplies from Gathering Grounds.

Where several houses are aggregated together in a village, some of which would be occupied by persons requiring a larger supply than is sufficient for cottages, a more organised system would be required and could be carried out more economically than by a number of separate rain-water tanks. Where no natural springs or similar sources of supply are available, collecting grounds and storage reservoirs must be resorted to. Speaking generally, every acre of drained land in this country may be taken to yield about 45,000 gallons, allowing only two inches to be stored out of the total rainfall. The proportion of population in the rural districts to acreage allows about 1·64 acres to every person, so that the supply is far in excess of the demand. For the supply of a small village, with mansion,

vicarage, garden, stables, farmsteads, and cottages, a gathering ground of from 50 to 100 acres would be ample, and a reservoir 7 feet deep and 150 feet square contain two millions of gallons, sufficient for a daily supply for six months. The lakes and fish-ponds to be found in the grounds attached to almost all large mansions afford at once ready-made reservoirs, with a full available supply, if arrangements be provided for filtering the water. It is more than probable that many of these lakes and fish-ponds were originally devised by the abbots and monks belonging to the monastic institutions, who, in all such matters, showed a practical skill and forethought that has been too little imitated by those who succeeded them.

In flat alluvial districts, where the water in the outfall ditches is so near the surface of the land as not to afford sufficient depth for the purification of the rainfall, from the manure and other organic matter with which it would come in contact, and also on peaty soils, and in other similar cases where no suitable natural collecting grounds can be obtained, the difficulty may be overcome by constructing artificial collecting areas covered either with slates, concrete, asphalte, or other impermeable surfaces. The extent of these would, of course, be regulated by the rainfall of the district, nearly the whole of which might be relied upon. Mr. Easton has lately constructed at Ashton Court, in Somersetshire, a catchment area of concrete, covered with cement, half an acre in extent, with a tank for the supply of the mansion. His calculation is, that three-fourths of the rainfall will be stored, and that this ground will yield a supply of 500 gallons a day. When collecting grounds of this character are used, the size of the storage tanks will, of course, be very considerably reduced. As there would be no absorption, the rainfall of the summer months would be equally available with that which falls during the rest of the year, and the consequent decrease in the cost of the tank would go a long way to pay for the expense of the construction of the gathering ground.

Wells.

The supply from wells, notwithstanding the fact that this source was considered by the Rivers Pollutions Commissioners as the most desirable, is not suited to the requirements of a rural population, when other sources are available. Shallow wells, whatever precautions may be taken, are always liable to the risk of contamination from sewage percolation. The water of deep wells is frequently hard, and unsuited for washing, for making beer, or tea, or similar domestic purposes. When this is the case, cottagers will always be found to avail themselves of a supply from a neighbouring brook or pond, even although it may be considerably polluted. The labour also of lifting water from a deep well will cause them to give the preference to the more easy means of supply. As an instance of this, it is stated that the inhabitants of the villages in Oxfordshire, where the water is obtained from deep wells in the chalk, rather than be at the trouble of undergoing the slow and laborious process of lifting it by hand, prefer taking their drinking water from the surface ponds, in which road drainage collects during rainy weather, and whence they can dip it with little labour.

Springs.

In many localities there are springs within a moderate distance of a village, and at sufficient elevation to allow of the water being conveyed to the houses by gravitation. All that is required in this case is a small collecting tank at the head of the spring, iron pipes for conveying the water, and stand-pipes near the cottages. Numerous instances could be quoted where simple works of this description have been carried out, either by private enterprise or by Rural Sanitary Authorities, the cost varying with the distance the water has to be brought, and the number of houses supplied. A typical case is given in the report of the Committee already referred to, of a supply for a village of 20 cottages with some better class houses, as rectory, farm houses, &c.; the spring being a quarter of a mile distant, the tank made to hold 1,200 gallons, the pipes of cast iron $1\frac{1}{2}$ inches in diameter, the water supplied to the cottages by stand-pipes with keys, and to the other houses with half-inch galvanised iron pipes, the total cost £75. The interest on this, at £6 per cent., and allowing for repairs, would make the charge one penny per week, to the cottagers, and four pence per week to the four other houses.

This is the simplest form of supply, where no easement has to be paid for the water, and the spring within a short distance. Taking the number of inhabitants at 120, the cost is only twelve shillings and sixpence per head. The average, however, may be taken at from £1 per head, or £5 10s. per house, under favourable circumstances, up to £3 per head, where water has to be paid for and lifted, or brought from a very considerable distance.

Raising Water by Mechanical Means.

Where the source of supply is below the level of the village to be supplied, it is necessary to resort to mechanical means to raise the water. When there is an abundant supply, this is most economically done by means of a ram, but where the quantity is large a water-wheel and pump are found more efficient. The cost of a supply with a ram will depend on the quantity required and the length of piping. Mr. Hett, of Brigg, has furnished me with particulars of rams fixed by him for the supply of houses, and gardens, varying from £92 10s., with a lift of 200 feet and 1,800 feet of piping, and yielding 1,440 gallons in 24 hours, to £26 for 273 feet of piping, and 1,700 gallons. As rams force up a portion of the same water which actuates them, they are only suitable for use where the water is pure. Water-wheels, on the other hand, can be worked with any water that is available. Mr. Goslin (of the firm of Messrs. Warner & Co.) has furnished me with an instance of a water-wheel working treble-barrel pumps, for the supply of pure water, for a mansion, homestead, gardens, stables, &c., the motive power being sewage; and in another case where the water is taken from the lake and duck pond, to pump the pure water from a well. Of the wheels and pumps fixed by Mr. Hett, the cost varied from £76, for supplying 1,700 gallons a day through 1,200 feet of inch pipes, with 90 feet lift; the fall for working the wheel being 5 feet, to £133, for supplying 1,200 gallons through 1,600 feet of piping, with 165 feet lift. Mr. Clutton

stated that the cost of fixing water-wheels eight feet in diameter, in the neighbourhood of the Cotswold Hills, for the supply of farm premises and cottages, was from £50 to £70.

In level districts, where no fall of water can be obtained, other means must be resorted to, and no more economical power can be used than wind. As nature has so admirably adapted her supplies of water to our wants in the case of the rainfall, so there is provided in the water or the wind a ready and effective power for lifting it up out of the underground storage reservoirs, the ingenuity of man only being required to apply the force in the most economical manner. Wind engines were formerly much used in the Fens for pumping the water off the land, but have now very generally been superseded by steam. Some few mills still, however, remain. They may frequently be found in this country in brick yards for pumping the water out of the pits, and are coming much into use for farm work. In America and the Colonies they are much more generally used than in England, many of the stations on the long lines of railway depending entirely on them for their supply of water; the irrigating channels on the rice fields being fed by the same means. A wind engine wastes no water, requires no fuel, and is economical in working; but as the wind cannot always be depended on, it must either be supplemented by horse or other power, or storage equal to at least a week's consumption provided. Mr. S. B. Goslin has furnished me with examples of several kinds erected by his firm. At Earlswood Asylum the water for the supply of 500 inmates has been raised by a wind engine erected several years ago. At St. John's Foundation Schools, near Leatherhead, the water is raised from a deep well to cisterns in the roof for the supply of 150 persons. A wind engine of their make also pumps the water from a well 200 feet deep for the supply of about 40 houses, cottages, and a mansion, at a cost, including pipes, of £263. At Portishead they also erected a wind engine and pumps for the supply of the village. Numerous other instances could be quoted, and it may be added that, at Margate, Faversham, Bridlington, and other places, windmills are used to pump a portion of the water supply, thus saving a considerable amount of fuel. I may also state that Messrs. Warner have lately erected, under my direction, a wind engine, for pumping sewage from a village for irrigation, and that Messrs. Hett are supplying a similar machine, supplemented by horse gear, for the sewerage works of a small town. The cost of both these engines, including pumps and fixing, was about the same, £100.

The use of the steam engine for the purpose of lifting water has not been dealt with, as being beyond the scope of the small class of works treated of in this paper; not so much from the first cost of the engines, which might not be more than those worked by either water or wind, but on account of the cost of attendance and maintenance. Wind and water are both self-acting, and require little attendance and no fuel, whereas steam engines require continual supervision and feeding; and this, together with the fuel and repairs, make the charges of maintenance so great as to preclude its use for small works, unless the engine be used for other purposes.

Means by which Works can be Provided and Cost Defrayed.

The duty of providing the supply and the necessary machinery must devolve either on the owners of the property or the Rural Sanitary Authority. A third course is where several owners have joined together and formed themselves into a company, under the Limited Liability Act. In the first and last case the works may be so carried out as to be remunerative. By the power of the Lands Improvement Act, of 1877, facilities are given to land owners of limited interest, with the consent of the Enclosure Commissioners, to borrow money and charge their estates with its repayment over a number of years for the construction of works necessary for water supply for their own estates or for villages. Also under the Enclosure Acts power is given to provide for the supply of water. Thus, in the enclosure of Coaley Common, works were carried out, consisting of a receiving tank to collect the water from a spring, and pipes laid to take the water to the village, with stand-pipes for its distribution, the cost, £750, being defrayed by a rate levied on the persons claiming under the enclosure of the Common.

The following may be quoted as some amongst many where landowners have themselves executed the works. In the evidence given before the Committee on River Conservancy, will be found a description of the works executed by Mr. McTurk for the supply of a village of 800 people, by laying down three miles of iron pipes connected with a reservoir, supplied by a spring, at a cost of £1,000. One hundred and twenty tenants used this water, the charge varying from five shillings a year for a cottage to twenty shillings for a farmhouse. The total rental was £70, which was sufficient to pay five per cent. on the outlay and provide for a sinking fund.

The Prince of Wales, at Sandringham, has provided a complete system of supply for the house and the cottages on the estate. The water is conveyed from a spring, rising out of the chalk, through 750 yards of nine-inch earthenware pipes to the pumping station, where it is forced to a tank at the top of a tower 60 feet high, situate about a mile from the house. By this means ample pressure has been provided for the discharge of water over the house in case of fire.

The Duke of Bedford, at Thorney, has had works constructed for a complete water supply for the village, including the erection of an engine-house, with two 25 horse-power engines, tanks for holding 10,000 gallons of water, filtering beds, and other works. The engines are used also for pumping sewage for irrigation and other purposes. At Tavistock also, the Duke of Bedford has constructed reservoirs for collecting the spring water, and supplying it on the constant system to 751 houses at a cost of £700. The rate charged is $2\frac{1}{2}$ per cent. on the rateable value of the houses.

On Lord Brownlow's estate, at Ashridge, a 28 horse-power engine, working three throw pumps, drawing water from a well in the chalk 255 feet deep, has been erected under the direction of Mr. Easton, C.E., for the supply of the mansion and farms, and villages adjacent. The total cost of these works was over £11,000, and the average amount of cost for repairs, attendance, &c., £430 a year.

The urban district of Bakewell, in Derbyshire, with 2,283 inhabitants, is supplied by water from works erected by the Duke of Rutland. Dunkeld, having 783 inhabitants, is supplied by pipes, bringing water from a burn in the hills, three miles away, laid down at the expense of the Duke of Athole.

Several instances of works carried out by the Rural Sanitary Authorities, for the supply of villages, will be found in the appendix to the report of the Select Committee of 1878, the cost being charged on the rates of the whole of each parish.

Where several owners are interested in providing the supply, the difficulty has been overcome by making use of the powers of the Limited Liability Act. Instances of this are given by Sir Harcourt Johnstone, as carried out on estates in which he is interested in Yorkshire. One company spent £1,040 for the supply of 500 persons, and another about £400 for the supply of 270 persons. The rental for the use of water is fixed at a sufficient rate to pay interest and maintenance of works, and averages about one shilling in the pound on the rateable value, or from 4s. 6d. to 5s. for a cottage.

Another case may be taken of Minehead, a small town with a population of 1,800. The total cost of the works was £3,400, or about £1 18s. per head. Numerous other similar instances will be found in the appendix to the sixth report of the Rivers Pollution Commissioners. This case is quoted to show the facility with which the water supply of small localities may be dealt with, where there is the desire on the part of the inhabitants to assist in carrying out sanitary work.

Necessity for Regulating Rivers and Maintaining the Water Level.

Before bringing this paper to a close, I wish to direct attention to a matter in connection with water supply which, in my opinion, is of vital importance. The disastrous floods of the last few years have raised a cry for improved drainage which, if not carefully watched, will lead to the drying up of our springs and wells, and cutting off the natural sources of supply. The maintenance of the underground water level has been too much lost sight of in this cry for thorough drainage. So far as the tidal influence extends, this will always be provided for. The inflowing volume of tidal water, running up a river twice every 24 hours, has a most powerful effect in checking the flow of the underground currents, and consequent exhaustion of the storage reservoirs. The hydrostatic power of the high tide, in fact, drives the water in these subterranean channels back, so that there may be said to be a corresponding rise and fall of the underground streams coincident with that in the sea and tidal rivers. This influence extends for a considerable distance inland. In the great alluvial districts on the east coast, the subsoil of which consists of silt, a porous soil, through which water can easily flow, the wells are affected for several miles inland by the tides, the level of the water being higher in spring tides, and lower during neaps, so that it is invariably the practice to sink wells during neap tides. Again, on the west of these alluvial plains is a range of chalk hills and oolite formation, the water from which flows underground to the Wash. In the northern part of the plain, these streams are tapped at about 100 feet below the surface, and the water-level in the wells rises and falls with the tides in the ocean. The wells sunk along the high land known as the Cliff, extending from Grantham to Lincoln, which are from 100 to 150 feet deep, are affected by the state of the River Trent, which is 12 miles away, the River Witham intervening. The water commences to rise in these wells a very short time after the flood waters have risen in the Trent.

Beyond the influence of the tidal current, this underground water-level can only be maintained by holding up the water in the main streams and arterial drains. This can be accomplished either by fixed or moveable weirs, the streams thus becoming reservoirs, not only advantageous for preventing the over draining the water from wells and springs, but as providing storeage for the supply of houses and farmsteads, for affording motive power to machinery, and also for irrigating the land in the dry season. The immense impetus given to all mechanical work by the use of steam, has caused the more simple and natural agents of wind and water to be neglected. By one or other of these, the whole operation of pumping water, grinding meal, cutting chaff, thrashing corn, and other similar work, could, in many cases, be performed at a trifling outlay. The first cost of conveying water from a stream situated at a level above the farmstead by means of pipes, to a water wheel or other engine, would be less than that required for the purchase of a steam-engine, and the working cost afterwards wholly in favour of the water power.

Again, for irrigating and fertilising purposes, water is a most valuable agent, and far too little appreciated in this country. The large crops and high rents commanded by land in the Fens is due in a very great measure to the constant supply of water that is maintained during the summer in the drains, which holding up the water level, affords a supply of moisture to the roots of the growing crops. The whole level is intersected by large arterial cuts, or drains, the larger being of sufficient size to be navigable by barges; from these radiate small drains, and from these again the ditches which form the fences and boundaries of the fields. The larger drains, where they discharge into the tidal stream, are provided with sluices with self-acting doors available in floods, and also draw doors, which are put down directly the floods are over, the height being so regulated as to maintain the water at a fixed level, generally about three feet below the surface. The drains are supplied by feeders from the upland streams, which replace the waste from absorption and evaporation during summer. The extent to which this takes place may be gathered from the fact that in dry years no water at all passes out of the River Witham during the summer months, the doors for holding up the water being placed across the river about eight miles above its point of discharge into the estuary. During the dry season of 1864, these doors were closed for several months, and it was not until the month of December that there was any flow of water down the river to the sea, although the Witham has a drainage area of more than eleven hundred square miles, and is fed by a large number of perennial streams.

It may be urged that, to hold up the water in our rivers and streams generally throughout the country would be prejudicial to health, and be the cause of disease and sickness. So far as the Fens are concerned, the contrary facts show the fallacy of any such idea. Previous to the enclosure of this tract of country, when water was lying stagnant in pools and morasses, and the sun acted on the decaying vegetation, fever and ague were generally prevalent. Since a complete system of drainage has been carried out, these diseases have entirely disappeared. Malaria is most intense immediately after water has left the surface of soil charged with decomposing organic matter. Hence the evil effects of occasional floods on land lying by the side of rivers. Intermittent fevers are engendered by alternate flooding and drying up of the meadows, but not by the constant presence of water. The Fen district having become drained and cultivated, the periodic inundations have ceased, and the organic matter has been assimilated by the constant process of cultivation, and forms the basis of the rich pastures and arable land. The large proportion of ozone in the Fen atmosphere, the physique and longevity of the inhabitants, and the small proportion of zymotic diseases, all testify to the healthiness of the district, and to the fact that holding up water in the arterial drains and water courses, while decidely beneficial to vegetation, is in no way injurious to health.

The experience gained in the drainage and water arrangements of the Fen districts may be usefully applied to other parts of the country. Our rivers should be made of sufficient capacity to carry off floods without damage to the surrounding land, and yet have their normal channels so regulated that the diminished quantity of the succeeding period of dry weather shall not have to meander hopelessly through a channel far too large for its requirements. The water level should also be so maintained, that the spring and underground reservoirs may be enabled to retain their stores and part with them only in such quantities that they may last out till replenished by the rain of the succeeding year; thus making the abundance of one season supply the deficiencies of another. It is not drainage or storage only that requires consideration, but both. They are not incompatible, but each may be provided efficiently by a proper regulation of the rivers and water-courses.

ON THE UNDERGROUND WATER-SUPPLY OF VILLAGES, HAMLETS, AND COUNTRY PARISHES OF THE CENTRAL AND EASTERN COUNTIES OF ENGLAND.

By Professor Edward Hull, LL.D., F.R.S.,

Director of the Geological Survey of Ireland.

That the development of zymotic diseases in villages and rural parishes is due to "dirt," which, as Lord Palmerston defined it, is "matter in the wrong place," and also to bad water, is an axiom that is accepted as soon as stated. Few, however, except those whose lives are passed in such localities, are aware to how large an extent these preventible diseases are prevalent, even in places where beneficent Nature has granted all the necessary aids to health. The stagnant pool, the pestilential manure heap, the odoriferous ditch, are but too frequently the immediate surroundings of a cottage or farmstead: and in the midst of these, or near thereto, is often planted the pump for the water-supply of the household, which, with the purer underground waters drawn from wider areas, again brings to the surface some proportion of the percolating filth.

On the other hand, where the geological conditions permit, many villages and hamlets are supplied with water from perennial fountains or deep wells; which, drawing their waters from wide areas of strata, through which the rainfall has percolated by the natural process, have thereby become suited for use. In the early planting of these islands, such fountains were generally selected as the sites of hamlets or homesteads, and many of these remain to the present day, along the borders of the chalk, the lower Greensand, and the Oolites; while, within the area of the London basin—as Prof. Prestwich has pointed out—many of the suburban villages near the city of London were grouped around a spring of water, or bed of gravel, from which water could easily be drawn by shallow wells.*

Before entering further upon the subject of this communication, I wish to premise that I have no intention of dealing with the question of water-supply to large towns, or any of those places which would come under the head of "Urban Sanitary Districts" of the Public Health Act of 1872. Such districts and towns may well be relegated to the care of their respective sanitary authorities, guided by a corps of engineers, who are ever ready to find water if only the money for the purpose is forthcoming. It is to the more humble and greatly neglected villages, hamlets, and country parishes of the central and eastern counties my observations are intended to apply, with a view of showing that the means are generally available for providing them, where required, with that essential concomitant to health, decency and comfort—good water.

Physical Considerations.

Though large portions of those districts of England referred to in this paper are destitute of hills—the birth places of springs and fountains—yet it happens that the geological formations are arranged so as to constitute underground reservoirs for a large proportion of the ordinary rainfall, which can be rendered available by wells of greater or less depth. These districts are composed of the mesozoic or secondary formations, consisting of alternating beds of permeable, or water-bearing, and impermeable, or dry, strata; generally arranged with such a moderate dip as to spread over large areas; and capable of retaining, on the one hand, or throwing off, on the other, a certain proportion of the rainfall, varying in amount according to circumstances.

The water-bearing strata consist of sandstones and limestones of various kinds; the impermeable, or non-water bearing, of clays and shales; and it is therefore evident that any system of water-supply applicable in the one case would not be so in the other. Accordingly, the subject divides itself into two heads, viz., supply by means of wells, and supply by means of artificial reservoirs or tanks.

The capabilities of the mesozoic (or secondary)

* Anniv. Address, Geol. Soc. Lond., 1872.

formations from the chalk to the new red sandstone inclusive, for furnishing permanent supplies of pure water, are being energetically investigated by the Committee of the British Association, "for investigating the circulation of underground waters," of which Mr. De Rance, F.G.S., is the Reporter. Four valuable reports have now been issued, and the investigations of the Committee originally restricted to the New Red Sandstone and Permian formations, have, since 1877, been extended to the Jurassic or Oolitic formations.

In the report for 1878, reference is made to the Congress on Water Supply held by the Society of Arts, and Mr. De Rance quotes his estimate of the areas of the formations yielding underground waters which he laid before that Congress, and which are as follows:—

	Square miles.
Permian and Trias (New Red Sandstone)	8,645
Oolite limestone, &c.	6,671
Hastings sand (Wealden) Greensand and chalk	11,371
In all	26,371

He states that, probably, four-fifths o the area of permeable rocks would yield, were they tapped, unpolluted water, and would receive into their mass not less than from ten to fifteen inches of rain water annually; a quantity which, if only six inches in depth were drawn from wells, would yield no less than 240,000 gallons per day for each square mile of surface, and which would be far in excess of the requirements of the population.*

This is, no doubt, a theoretically correct estimate, and although the available supplies may be far below it, enough has been said to show that the underground reservoirs are of vast extent and resources.

(1.) Permeable (or Water-bearing) and Impermeable (or Dry) Formations.

So much has already been written upon the nature of these formations, and the qualities of the waters they are capable of yielding, that I shall content myself with a very brief description of them; commencing with the chalk formation downwards (see Table).

Out of the twelve sets of strata, arranged in the following table according to their water-bearing qualities, there are seven which are permeable, viz.:—(1) Chalk and upper Greensand, (3) lower Greensand, (4) Purbeck and Portland beds, (6) Coral rag and grit, (8) Oolites and upper Lias sands, (10) middle Lias, (12) New Red Sandstone, with a total thickness varying from 1,275 to 5,500 feet, while there are alternating with the above five sets of strata, which are impermeable, viz., (2) Gault clay, (5) Kimmeridge clay, (7) Oxford clay, (9) upper Lias clay, (11) lower Lias and Keuper marls, with a total thickness varying from 2,110 to 5,430 feet vertical.†

* Reports, p. 2.

† I have purposely omitted the clays and gravels of the drift series, as they are of so variable a nature that no general rule can be laid down regarding their water-bearing qualities. The boulder clay is, however, a generally impermeable stratum, and the middle sands and gravels water-bearing; from these springs good soft water often issues forth.

Geological Formations of the Central and South-east Counties.

	Formations.	Permeable Strata.	Impermeable Strata.	Quality of Water.
		Thickness in feet.	Thickness in feet.	
1	Chalk	645 to 1,000	..	Hard
	Upper green-sand	100 to 400	..	Rather hard.
2	Gault clay	..	130 to 200	..
3	Lower green-sand*	20 to 500	..	Soft and good.
4	Purbeck and Portland beds	0 to 60	..	Rather hard ?
5	Kimmeridge clay	..	300 to 600	..
6	Coral rag and grit	40	..	Rather hard.
7	Oxford clay	..	350 to 500	..
8	Great and Inferior Oolites	200 to 450	..	Hard.
	Upper Lias sands	20 to 200	..	Soft?
9	Upper Lias clay	..	30 to 300	..
10	Marlstone or middle Lias	30 to 250	..	Rather hard ?
11	Lower Lias clay	..	500 to 600	..
	Keuper marls (Trias)†	..	600 to 3,000	Gen'ly imper.
12	Lower keuper sandstone‡	150 to 450	..	Soft.
	New red sandstone (Bunter)§	0 to 2,150	..	Soft or variable.
13	Lower Permian beds (alternating characters	Variable	Variable	Soft.

(2.) Qualities of the Waters from the Permeable Strata.

In endeavouring to ascertain the qualities of the underground waters derived from different formations, it may be generally assumed that those drawn from limestone formations are "hard," and those from sandstone "soft." Owing, however, to variations in the nature of some of the strata in different localities, and to the greater or less proportion of carbonate of lime, carbonate of magnesia, or salts of iron, &c., which they contain, the quality of the water from the same formation is liable to variation, according to locality. This subject has already been so fully dealt with by various authors, that I do not consider it necessary to do more than give a brief summary of the results, as far as they have been ascertained, in several localities.

(a.)—Water from the Chalk.

From analyses of many wells and springs in this formation in the South-east of England, it is well-known that "chalk water" is hard, though clear and well suited for many purposes, especially in the important one of brewing. The percolation of

* The lower Greensand of Surrey consists of several members of varying hydrometric qualities, for an account of which see "Geology of the Straits of Dover,' by W. Topley, F.G.S.; and "Horizontal Wells," by W. Lucas, p. 21.

† The beds of Keuper sandstone about the centre of the marls often contain water. In the Scarle boring, a feeder of water yielding 11 gallons per minute was struck in these beds at a depth of 790 feet.

‡ In Scarle boring about 250 feet thick.

§ Scarle, 540 feet.

the rain through this formation, amounting to about one-third of the actual rainfall, is so exceedingly slow, that the water has abundant time to take up a large proportion of carbonate of lime from the rock itself. The mode of percolation has been ably treated by Professor Prestwich,* Mr. Clutterbuck,† Mr. Homersham, C.E.,‡ and others. It seems, from observations made on the chalk hills by Mr. Beardmore,§ that it takes from four to six months for the rain to reach a depth of 200 to 300 feet, so that the water which is drawn from this depth in summer belongs to the rainfall of the preceding winter. The total quantity of solid matter in chalk water varies from 31 to 32½ in 100,000 parts, of which from 16·4 to 21 parts are of carbonate of lime. In the case of large works, this mineral ingredient can be dealt with by the softening process invented by Dr. Clarke; but for country villages, there seems to be no plan of easy application for lessening the amount of calcareous matter, except that of boiling, by which the hardness is reduced from 24·7 to 3·7 in extreme cases.

(b.)—Upper Greensand.

The water from the upper Greensand is probably a little less hard than that from the chalk.

(c.)—Lower Greensand.

The water from this formation is generally considered unexceptionable, and decidedly "soft." Samples taken from five localities, give a mean result of 7·9 of solid matter in 100,000 parts of water. Mr. Bateman, C.E.,‖ speaks of the water from this formation in the basin of the Wey as being of the greatest purity; and as the sands are generally loose and incoherent, they absorb nearly all the rain which falls on their surface, except that given off by evaporation, or imbibed by vegetation.

Enormous quantities of water are absorbed by this formation, where, as in Surrey and Kent, it is largely developed, and to such an extent are they capable of being rendered available, that Mr. Lucas proposes by means of tunnelling, to render them useful for the supply of London.¶ In Bedfordshire, Bucks, and Berks, as also in the S.W. of England, the formation attains large proportions, and contains bands of siliceous iron ore, which to some extent affects the water. Exposure to the air, however, causes the iron to be precipitated.

(d.)—Oolite Limestones.

The waters from these formations are more or less hard, yet less so than those from the chalk, and of course, where the source is the sandy strata which accompany the limestones of the Portland Oolite, the great and inferior Oolites, &c., the qualities of the water will be found to vary accordingly. Of the proportion of solid matter in the waters of the Oolites, that found in the fine springs of South Cerney, near Cirencester, which rise along the line of a large fault, may be taken as a sample. The total amount of solid matter was found to be 18 grains per gallon, of which 1·25 was of organic origin.* The water from the Seven Springs near Cheltenham, from the inferior Oolite, gave six grains per gallon, of which two grains consisted of organic matters.† The well at Thames Head, pumping from the great Oolite near Cirencester, gave 16 grains per gallon;‡ and the waters of the Chelt, above Charlton Mill, near Cheltenham, which rise from springs at the base of the inferior Oolite, gave 20 grains per gallon, of which four grains consisted of organic matter.

(e.)—New Red Sandstone.

Next to the chalk, the New Red Sandstone—including the Bunter and Lower Keuper divisions—is the most important water-bearing formation in the district under consideration, and the water which it yields possesses this advantage over that of the chalk, that it is softer, and generally capable of being used for all domestic and manufacturing purposes. From the numerous analyses that have been made of these waters in different localities, in the central and N.W. counties, we have the means of arriving at general conclusions on this subject; and for special and accurate details, we may look forward with interest to the Reports of the Committee on Underground Waters, appointed by the British Association in 1874.§ The beds of the Bunter sandstone are wonderfully adapted to act both as natural filters and as reservoirs for that portion of the rain which sinks below the surface. This may be assumed at one-third of the actual rainfall as an average; while in some districts—where the formation consists of soft sandstone, or unconsolidated conglomerate, devoid of a thick covering of drift clay—the amount of absorption must reach well nigh one-half the amount of rainfall. Owing, also, to its uniformity in composition, and the absence of beds of clay or marl of any importance, the whole mass of rock below a certain level, and throughout a depth of several hundred feet in some districts, becomes water-logged; and wells sunk therein do not (as in the case of the chalk) generally depend for their supply on the presence of fissures, but water is nearly always found after the "water-level" of the immediate district has been reached.

The remarkable permeability of this formation, equalling, probably, that of the lower Greensand both of England and France, has recently been illustrated by the deep boring in search of coal at Scarle, near Lincoln. This boring, conducted by the "Diamond Boring Company," was commenced in the lower Lias in 1874, and, after having passed through 790 feet of these beds, and the underlying impermeable marls of the Keuper, struck a feeder of water in the lower Keuper sandstone, and a still stronger one at 950 feet, which caused the water to spout up 5 feet above the surface. The whole of the Bunter sandstone below was also charged with water, as proved by the increasing temperature down to its base of 1,500 feet from the surface. Now, the distance of this boring from the outcrop of the beds towards Mansfield, varies from 12 to 16 miles, and through

* Anniversary Address, 1872, p. 41.
† Proc. Inst. Civ. Engineers, 1842-3 and 1850.
‡ Report Royal Commission on Water Supply, 1869.
§ *Ibid.*, p. 204.
‖ Report contained in a Return to an order of the House of Lords, 1852, No. 258.
¶ Horizontal Wells, by J. Lucas, F.G.S. (1874).

* Analysis, by J. Horsley, F.C.S., appended to Report on the water supply of Cheltenham, by Dr. Wright, F.R.S.
† Horsley's Analysis. See, also, Prof. Prestwich, "On the Geological Conditions arecting the Water Supply of Houses, &c." (Parker and Co., Oxford), 1876.
‡ Horsley's Analysis, Sup. Cit. p. 8.
§ Belfast Meeting. First Report presented at Bristol, 1875.

this distance the water percolated from a district 300 or 400 feet above the sea-level, till it reached a depth of about 900 feet below it; and, being kept down by the overlying impervious beds of Keuper marl, ascended to the surface with great force on the artesian principle, on being released, through means of the bore-hole.*

The amount of solid matter per gallon in the waters of the new red sandstone varies from six to fifteen grains, where they have been taken from wells not too shallow, or from those which are free from contamination by sewage pollution or other causes. It is to such a cause that the large proportion of saline and other ingredients in some of the Liverpool and Manchester wells, amounting in some instances to 24 and 36 grains per gallon respectively, is attributable. In general, the proportion of these ingredients occupies a central position between those of the chalk and other limestone formations on the one hand, and the surface waters of mountain districts, composed of millstone grit or of silurian rocks, on the other. The following examples will probably be considered sufficient for the purpose here intended:—

	Wells or springs.	Grains per gallon.
Liverpool district†	Bootle	24·00
,,	Soho	24·80
,,	Windsor	23·22
,,	Green-lane	13.60
Birmingham‡	Aston	12·82
Stourbridge§	Well of W. W. Co.	21·95
Leek (Staffordshire)‖	Wall Grange Spring	12·26
Whitmore (nr. Crewe)¶	Well of London and North-Western Ry.	6·10
Parkside (near Warrington)**	Well	11·12
Nottingham	Several wells (suburban)	12·0 to 16·0

As an illustration of the effect of the percolation of saline matters on the waters of even deep wells in large towns, I give here the analysis of the waters of a well from the south side of Manchester, made in 1865 by Dr. Angus Smith, F.R.S. This will show the desirability of having all wells, as far as possible, removed from such sources of contamination:—

WATER FROM WELL, MANCHESTER, SOUTH SIDE.

	Grains per Gallon.
Cloride of sodium	4·88
Sulphate of soda	7·33
Carbonate of soda	7·35
,, of lime	9·77
,, of magnesia	5·29
Phosphoric acid, potash	traces.
	34·65

Lithia discovered by spectroscope.

This permeability is likewise exemplified by the condition of the Liverpool wells. There can be no doubt, from the observations recently made, that the saline ingredients are increasing in the waters of the wells, and that much of this water is derived by infiltration from the estuary of the Mersey. It is only on such grounds that the extraordinary supplies derived from these wells can be satisfactorily explained. This proves the desirability of having the wells sunk a good distance from the sea; and I venture to suggest that the plain of Cheshire, lying south of the Mersey, and so far as it is formed of New Red Sandstone, offers a source of supply as yet but slightly drawn upon.

On the other hand, the purity of the waters from the Aston well, the Wall Grange spring (yielding 3,000,000 gallons per day), the Whitmore, Parkside, and Nottingham wells—where removed from the influence of populous neighbourhoods—must be considered as completely establishing the excellence of this source of water supply.

Considering, therefore, the wide extension of the water-bearing strata of the New Red Sandstone, the excellence of the formation as a source of pure water—equally cool and refreshing in summer and winter—it must be conceded that the central counties are happily situated as regards their prospects of water supply, provided these resources are judiciously utilised. Nor must it be forgotten that the internal reservoirs do not terminate with the upper boundary of the Sandstone, but that the waters pass for great distances under the overlying impervious marls, as illustrated by the case of the Scarle boring, and that by deep wells or borings these underground reservoirs may be converted into perennial fountains.

(3.) APPLICATION OF THE ABOVE OBSERVATIONS TO THE CASES OF VILLAGES AND HAMLETS.

From what has been stated, it will be obvious that for those villages, hamlets, or parishes situated on any of these water-bearing strata, or not far from their upper margins, where they pass below the overlying impermeable formations, wells are the proper and available means of supply. But the determination of the question regarding the character of the formation underlying each special village or hamlet, as well as the selection of the best site for a well, are, evidently geological questions, requiring some special knowledge of this branch of science; and the problem how such knowledge is to become available in each case remains for solution. To this I now address myself.

In the first place, as admitted by Mr. Edwin Chadwick, C.B., the completion of the maps of the Government Geological Survey, over the districts comprised in this paper, places them in a very advantageous position for availing themselves of the underground waters stored up in the strata. Until some accurate and detailed maps, such as these were, rendered available, the data for arriving at definite conclusions regarding the geological situation of many localities, could not be obtained. With these maps, a Sanitary Board ought to be able, with very little assistance of a technical kind, to determine whether a particular village or hamlet requiring good water, was so placed, geologically, as to be able to obtain a supply by means of a well; and, if so, also the best spot in which such a well should be sunk.

I am aware, however, of the unhappy and prevalent ignorance of even the most rudimentary

* From information kindly afforded by Mr. J. T. Boot, mining engineer. Proc. Inst. C.E., vol. xlix., p. 1.
† Analysis by Richard Phillips, F.C.S.
‡ Analysis by Dr. Hill, F.C.S.
§ Supplied by Mr. E. Bindon Marten. This well is only 46 feet deep.
‖ Analysis by R. Phillips.
¶ This well supplies the works and populace of Crewe, and was sunk, on the recommendation of the author, by the London and North-Western Railway Company, 1864.
** Analysis by Dugald Campbell, F.C.S.

principles of geology amongst such bodies, and it would, therefore, be necessary, for the proper carrying out of the proposals here suggested, that an experienced geologist should be attached to the staff of the Central Board of Health in London, whose duty it should be, when applied to, to afford advice in all cases of this kind. Owing, therefore, to the progress of the Survey over the districts here alluded to, it seems to me that the time has arrived for putting in force some scheme of general application, depending on geological considerations.

(4.)—Cases not admitting of Supply by means of Wells.

I now come to the case of those villages, hamlets, or parishes, which, owing to their geological position, cannot be supplied by means of wells. These are they which are situated on such impermeable strata as the Oxford clay, the Lias, or the Keuper marls; or are at such a distance from the subjacent water-bearing strata, that the depth of a well would be great, and the expense too costly for the resources of the inhabitants. In such cases, a supply from surface drainage of some available brook or rivulet seems the only resource; and powers should be given by the local sanitary authority to impound such streams in small reservoirs or tanks, under proper and stringent regulations, so as to prevent surface pollution of the water, either in the stream or in the reservoirs. The construction of such small reservoirs as would be necessary for the purposes here alluded to, would entail only a moderate amount of engineering skill and of pecuniary outlay. In providing pure water it would also be necessary to stop up or destroy all impure wells, pools, or tanks, in the same village or hamlet, as the poor are very apt to prefer a source of supply to which they have all along been accustomed.*

(5.)—Machinery for Carrying out a General System of Water Supply for Villages and Hamlets.

We come now to the difficult question as to the machinery for carrying out such a system of water supply as is here proposed; and perhaps the first step to be taken is to ascertain to what extent the evil of insufficient or polluted water supply prevails in country places. This, I think, might be effected by means of the agency evoked under the Public Health Act of 1872. Under the clauses of that Act, the rural sanitary authorities have the power of appointing a medical officer of health and an inspector of nuisances for a period of five years; and it would probably not be difficult, by their co-operation to obtain returns from all the parishes included in the rural sanitary districts, together with the villages and hamlets contained therein. I would propose that a simple form of circular be drawn up by, the authority of the Local Government Board, which the officers above named should be required to fill up and return, stating—1st. The names of the villages or hamlets in each rural sanitary district; 2nd. The number of houses; 3rd. The existing mode of water supply; 4th. The opinion of the medical officers regarding the nature and quality of such water, if any there be; and, 5th. Observations regarding the general health of the inhabitants and the presence of zymotic diseases. It would then be the duty of the Local Government Board to eliminate the names of those villages or hamlets in which it would appear, from such returns, that the water supply was sufficient, both as regards quantity and quality; and then would remain those residuary cases, requiring to be dealt with under the scheme here proposed. They would probably be found to amount to several hundreds within the limits of the area dealt with in this paper.

It would doubtless be advisable, in carrying out such a scheme, that the existing Parliamentary powers should be called into requisition. After perusing the Public Health Act of 1872, it seems to me that, with slight modification, that Act might be made available. The division of the whole country into (1) urban and (2) rural sanitary districts is excellent, and at once determines the districts outside and within the scope of the proposals I have ventured to offer. The appointment of medical officers of health by the sanitary authorities, but who are responsible to the central authority in London, offers an effective agency. Under Clause 17, the rural sanitary authority has power to provide a supply of water for rural sanitary districts; but such districts are, I fear, too extensive for such modes of water supply as is here proposed, and it would be necessary to split them up into villages and hamlets, having independent powers, though the necessary expense might be spread over each district.

I would, therefore, propose that, when it is found from the reports obtained through the rural sanitary officers, that the supply of water to any village or hamlet is insufficient or impure, the sanitary authority of the district in which the village or hamlet is situated should be required to proceed forthwith to apply the remedy. It would be necessary then, in the manner I have ventured to suggest, to ascertain whether the locality could be supplied by a well, and if the local technical acquirements are insufficient to settle this question, the aid of such a Government officer as has been already referred to should be afforded; while at the same time it should be competent for the sanitary authority to call in professional advice from any other quarter.

A well having been determined upon when the geological conditions prove favourable, the site fixed with reference to local circumstances, and the cost having been ascertained, powers should be granted to raise money for carrying out the work, and rendering the well available for the free use of the whole of the inhabitants.

In sinking such a well, the top waters, to a depth of 10 or 12 feet, should always be carefully stopped off by solid masonry or hydraulic cement; and means be adopted for keeping it free from contamination, under stringent regulations and heavy penalties. Being for the use and benefit of all, it should be jealously guarded by all as as a public benefactor.

I have not considered it necessary to enter at length into the means by which my proposals should be carried out. These are matters of detail, capable of settlement by those who are conversant with such matters. I have contented myself with

* Such power is granted to the Local Sanitary Authority under the Act of 1872.

sketching out a plan of general application, which will probably be considered sufficient for the present occasion.

By one or other of the above methods probably all the villages or hamlets of the central and eastern counties which require it might be supplied with pure water. Till this is done, it cannot be considered that we have reached the state of sanitary improvement befitting a great and prosperous country.

WATERSHED LINES.

Subterranean Water-ridges.

By Joseph Lucas, F.G.S.

The surface-ridge which forms the western boundary of the basin of the Medway in the chalk area, marks also the position of the subterranean water-shed line from Cobham as far south as Meopham-green, a distance of four miles. The surface boundary ridge continues its south-westerly direction for another three miles to the chalk escarpment, near Wrotham; but the subterranean water-shed ridge takes a south-easterly direction at Meopham-green, and runs under a valley, and then by a slight curve along the course of the ridge through David-street, Harvel, and Sparrow Haugh, to the chalk escarpment in Down's Wood, one mile and a-half east of the point at which the surface boundary ridge reaches the escarpment. The subterranean drainage of the included triangle (physically within the Medway basin) flows towards the north-west, under the apparent boundary ridge, and then north to the Thames at Gravesend. The area thus lost to the Medway basin is rather over one square mile and a quarter.

From the point (south of Fairseat) at which the above-named surface boundary ridge strikes the chalk escarpment, there starts also the eastern boundary ridge of the so-called basin of the Darent. This ridge runs almost due north, through the heart of the chalk country, as far as Longfield-hill, a distance of four and a-half miles, after which it runs in a north-westerly direction to near Dartford, a distance of six miles, the last four being over tertiary strata. Unlike the last, this ridge, although inclosing the Darent basin, as viewed by the modellist, does not in any part of its course mark a subterranean water-shed line. On the contrary, it traverses longitudinally, at a small angle, an immense depression in the surface of the chalk water system, which forms the subterranean basin next adjacent to that of the Medway. This is the Stansted basin, which empties itself into the Thames near Gravesend.

The Stansted basin is bounded on the west by a broad ridge, under which there also lies a strong subterranean water-shed line. The chalk water system in this block of hills, between the Medway and the Darent, attains its greatest altitude at the southern extremity of this ridge, near Terry's Lodge Farm. The subterranean water-ridge can be traced north for four miles, or as far as Hartley, when it gradually disappears by the convergence of the Stansted basin and that to the west, or the Fawkham basin. The western boundary of the Fawkham basin is the surface-ridge running through Kingsdown, Chimhams, and Speed Gate, and thence towards the village of Darenth. A subterranean water-ridge accompanies this, without exactly coinciding with it, as far north as Horton Kirby, a distance of four and a-half miles, when it, too, becomes indistinct. This water-ridge forms the true eastern boundary of the Darent basin—the Stansted and Fawkham basins taking the waters of an area of 17 square miles from the apparent basin of the Darent under the surface ridge to the Thames direct.

The western boundary of the Darent basin, and, therefore, the eastern boundary of that of the Cray, is a remarkable line. There are few lines in nature so straight. The subterranean water-ridge runs almost absolutely straight for 11 miles. It corresponds generally in position with the surface-ridge, the following exceptions being noteworthy.

Where the surface-ridge runs along Well-hill, the outlier of tertiary strata, by cutting off direct access of rain to the chalk water system, throws the subterranean water-shed a little to the west. Again, from Crockenhill, the surface boundary ridge runs north by a curved course over tertiary strata, round by Joyden's wood. Since this mass of tertiary strata also cuts off the direct access of rain to the springs, the chalk water-ridge does not partake of the curve, but lies to the east, under Hextable and Oakgreen, Wilmington—the greatest divergence being one mile. The included area of nearly two square miles, therefore, drains into the Cray basin.

The western boundary of the Cray basin in the chalk area, and therefore the eastern boundary of the Ravensbourne basin, follows the surface-ridge from Holwood as far south as Cudham-lodge, south of which I have no good evidence as to its course. I incline, however, to think that it does not follow the surface ridge to the south-east, but more probably continues a south-westerly course, to the chalk escarpment, north of Limpsfield. If, after a closer survey, this should prove to be the case, the area of the included triangle, three and a-half square miles, will have to be subtracted from the basin of the Ravensbourne, and given to that of the Cray.

The western boundary ridge of the Ravensbourne basin in the chalk, runs south from the tertiary Addington hills, along a spur and an outlier of Thanet sand, by Selsdon and Sanderstead, having there a south-westerly direction. The subterranean water-ridge lies between them, having a south-easterly course. The surface ridge curves round to the west, but the subterranean water-ridge keeps its course by Kingswood-lodge and Kennel Farm, falling in with the surface-ridge at Worms Heath, whence they appear to run together to the escarpment. The included area is about a square mile and three-quarters. This feeds the Wandle basin, whose eastern boundary is thus described as far north as Selsdon, from which place it takes a north-westerly course—the surface-ridge along the tertiary strata, and the subterranean water-ridge outside by West Croham. Along the western boundary of the Wandle chalk basin, the surface and subterranean lines correspond generally nearly the whole way from Sutton to the chalk escarpment. North of Banstead, the water-ridge lies

rather to the west of the surface-ridge, and south of that place, a little to the east of the surface-ridge, which runs along tertiary outliers.

The Mole basin takes the drainage of the tertiary strata for a distance of seven miles measured along their base—four miles west and three east of Leatherhead, but it does not take any contributions direct from the chalk along the same line, the basin being fan-shaped and having its apex at Leatherhead. The area dispossessed on the east side is two and three-quarters square miles, and on the west side the same. These areas drain under the tertiaries. The subterranean water-ridge on the west side does not correspond with any surface-ridge, but lies north-west of that running down to Leatherhead, until it crosses it near Effingham-hill, after which it runs parallel to, and half a mile east of, the western boundary ridge of the basin, to the escarpment.

The Wey basin takes the drainage of 12 miles of tertiary strata, measured along their base, five west and seven east of Guildford; but the Wey at Guildford takes the drainage of a fan-shaped area of chalk country, not more than three-quarters of a square mile in extent, the drainage of the chalk range east and west passing under and over the tertiaries. The Wey basin also takes the drainage of the chalk from the western end of the Hog's-back to Dippenhall, west of Farnham, a distance of about four miles and a half.

In the chalk area of Hampshire, the basin of the Wey, as measured by the surface-ridge, is larger by twenty-eight and a half square miles than it is as measured by the boundaries of the subterranean water-ridge.

The subterranean water-ridge corresponds generally with the surface-ridge separating the basin of the Wey from that of the Loddon, as far as about one mile north-east of Shaldon. The surface-ridge then turns north-west, a direction which it holds for eight miles. Only the first three and a half of these are between the Wey and the Loddon. At Herriard, the boundary-ridge of the Wey basin branches south-west for five miles, and then turns due east for two miles to Medsted. The water-ridge, however, instead of following it round this course, runs straight across through Shaldon to Bentworth, whence a branch water-ridge between the Loddon and the Itchen runs north-west. The area thus cut off drains into the Loddon basin, and is four and a half square miles in extent. From Benthworth another branch of the water-ridge runs south to Medsted, cutting off a second area of $2\frac{1}{4}$ square miles, which drains into the basin of the Itchen. From Medsted, where the two ridges coincide, the surface ridge takes a southerly course, somewhat sinuous through Chalwood and Privet by Froxfield to the chalk escarpment at Stoner Hill. The subterranean water-ridge, however, strikes nearly straight across by a south-easterly course from Medsted to Nore Hill. At Farringdon it passes under a large valley, into which it occasionally rises, bursting about the out-crop of the lower chalk as a bourne which flows down the valley to Alton. In all the ramifying system of easterly sloping dry valleys above Farringdon, the water falls towards the west under the surface boundary ridge, and into the basin of the Itchen. The area thus cut off is $21\frac{3}{4}$ square miles, making a total of $28\frac{1}{2}$ square miles to be subtracted from the basin of the Wey in the chalk of Hampshire.

The water-ridge dividing the basin of the Loddon from those of the Itchen and the Test, lies to the south-west of the surface ridge, preserving a distance of about a mile and a half from it, from near Bradley, through Nutley, to Church Oakley, where it crosses the South-Western Railway. East of the railway, the Loddon basin receives the subterranean drainage of about nine square miles of chalk country, lying physically within the basins of the Itchen and the Test.

Table showing the Apparent and Real Areas of Chalk Country lying within the Watersheds of the several Basins named.

	Apparent Chalk Area.			Area proved to drain elsewhere.			Mean daily loss to apparent area at 6ins. absorbed per annum.	Extraneous Areas proved to contribute.			Real Chalk Area.
	Square Miles.			Square Miles.			Gallons.	Square Miles.			Sq. Mls.
	West side.	East side.	Total.	West side.	East side.	Total.		West side.	East side.	Total.	
*Medway	$22\frac{1}{2}$	..	..	$1\frac{1}{4}$	..	..	281,063	..	..	..	..
*Gravesend	..	..	40	..	..	..	..	17	$1\frac{1}{4}$	$18\frac{1}{4}$	$58\frac{1}{2}$
Darent	$23\frac{1}{4}$	41	$64\frac{1}{4}$	2	17	19	4,522,020	..	..	..	$45\frac{1}{4}$
Cray	..	..	$26\frac{1}{2}$	..	..	..	..	$3\frac{1}{2}$ (?)	2	$5\frac{1}{2}$ (?)	32
Ravensbourne	..	..	21	$1\frac{3}{4}$	$3\frac{1}{2}$ (?)	$5\frac{1}{4}$ (?)	..	..	..	..	$15\frac{3}{4}$ (?)
Wandle	..	..	$52\frac{1}{2}$	..	..	..	..	..	$1\frac{3}{4}$	$1\frac{3}{4}$	$54\frac{1}{4}$
Hogsmill River, &c.	..	..	13	..	..	..	..	..	..	..	..
Mole	14	9	23	$2\frac{3}{4}$	$2\frac{3}{4}$	$5\frac{1}{2}$	1,309,006	..	..	..	$17\frac{1}{2}$
Wey, Surrey	$7\frac{1}{2}$	11	58	..	..	..	..	..	..	..	..
,, Hants	$39\frac{1}{2}$	..		$28\frac{1}{2}$	..	$28\frac{1}{2}$	6,783,086	..	..	..	11
Loddon	..	..	83	..	..	..	..	9	$4\frac{1}{2}$	$13\frac{1}{2}$	$96\frac{1}{2}$
Itchen	..	..	$148\frac{1}{2}$	..	..	..	..	..	24	..	..
Hamble	..	..	12	..	..	..	..	..	..	..	..
Meon	..	..	$31\frac{1}{2}$	..	$1\frac{1}{2}$	..	357,000	..	..	..	30

*South-west of a line drawn through Gravesend and Strood

The southern boundary ridge of the Itchen basin marks the subterranean water ridge for, at least, four miles east of Millbarrow Down; the first two miles separating the Itchen from the Hamble, and the other two from the River Meon. East of West Meon the surface ridge probably also generally marks the subterranean water-ridge; but, if so, there must be a rapid northerly fall from it in the extreme south-eastern portion of the Itchen basin, in which the subterranean water is 50 feet lower than the River Meon at East Meon. The southern surface boundary ridge of the Meon basin lies a little to the south of the subterranean water-ridge, whose summit rises into the valleys on the northern slope of the hills, so as to cause springs, permanent tributaries of the Meon, high up those valleys, and within a mile of the ridge, whereas on the south side of the hill there are no springs nearer than the tertiary base, four miles south of the ridge. This is owing to the lower chalk outcropping on the north side of the hill, and the upper chalk forming the southern slope. The area thus lost to the Meon is about a square mile and a-half.

NATIONAL WATER SUPPLY.

By Joseph Prestwich, F.R.S.,

Professor of Geology in the University of Oxford.

I much regret that my engagements here will prevent me from being present at the Conference on Thursday and Friday next. I do not, however, know that I have anything to add to the communication I made last year on the subject of "Water Supply." It is one to which, on geological considerations, I feel much interested, while its importance on sanitary considerations cannot be over-estimated.

It is not only the purest springs and rivers that have to be sought, but it must also be borne in mind that the protection of springs from pollution is equally essential as that of rivers, and is even more difficult to guard against. If I may be allowed, I will quote the concluding paragraph of a lecture I had occasion to give before the University of Oxford, three years since, on this very subject, in which some of the dangers of our present system are pointed out, and the necessity of the steps the Society of Arts is now taking is alluded to.*

"The importance of a large and good supply of water cannot be over-rated. This, as a general proposition, is now fully understood, and in all our large and populous towns able engineers have constructed works to secure such supplies, and to do away with the abuses that were inevitable where, as formerly, each house was the centre of its own water supply and drainage. But, although the flagrant sources of contamination are generally removed from our large towns, they still too often lurk in hidden or forgotten corners, while in the hundreds of smaller towns and villages, and in thousands of country houses, the plague-spot still exists in almost all its foulness and intensity. The air may be pure, the country may be smiling, the waters may be bright, the people may be cleanly, ease and luxury may prevail on the surface, but below that surface a poison is, by a delicacy which is not unnatural, hidden out of sight, unknown to most, often kept in subjection for years, or working so insidiously as to raise no suspicion; but there it is ready, when the opportunity offers, to fix on its prey, and to spread disease and death around; the blow, in fact, is often so covertly given, that neither the sufferer nor his friends suspect when or whence it comes. The great outbreaks are exceptional. They unavoidably attract attention. But it is a question with me whether the sum of the minor resultant evils does not outbalance the more prominent cases. Against these many risks it seems nobody's business to guard.

"The evil is so widespread and so deep-rooted that I apprehend nothing less than legislative action will be able to effect a cure, and protect an unwitting population from conditions over which they, in general, have no control, and of which, without special inquiry, they cannot possibly have any knowledge."

I am truly glad that this great question—which is one of primary national importance—has been taken up by the Society of Arts, and sincerely trust it may attract the attention and support it deserves.

* "On the Geological Conditions affecting the Water Supply to Houses and Towns, with Special Reference to the Modes of supplying Oxford." Parker and Co., Oxford, 1876.

RIVER CONSERVANCY.

By Professor D. T. Ansted, M.A., F.R.S.

The Bill brought into Parliament by the Duke of Richmond, on River Conservancy, and already passed by the House of Lords, seems to show that this important subject is at length seriously considered, with a view to legislation either in the present or an early session. There are points worthy of consideration concerning the objects attainable by proper conservation of streams, and the duties of conservators, that may fitly be discussed at the present Congress.

One of the first of such points is to determine the grounds on which rivers, or groups of rivers, may be best brought into combination for purposes of conservancy. A division of our country into natural and convenient groups of catchment areas of moderate extent is essential for this purpose, and must be generally admitted as a preliminary step. The offer of the Council of the Society to give medals for useful suggestions to this effect can hardly fail to result in some agreement on the subject.

Assuming that some system of grouping is agreed on, and that the whole country is parcelled out into a moderate number of conservancy districts, the next point is to determine the objects of conservancy. We may take for granted that any recognised mode of grouping catchment areas must include, among primary districts, the basins of our great rivers. The basin of the Thames and that of the Severn, the basins of the Trent and the Yorkshire Ouse, and probably the basins of the Great Ouse, the Mersey, and the Ribble, would be regarded as requiring, in each case, a separate staff. There are certain conditions of rivers, common to all these, that will enable us to point out fairly enough the requirements of conservancy, and the matters that need consideration on the part of Conservators.

These requirements will certainly include the following very distinct subjects, concerning each of which supervision is needed on behalf of the public:—

(1.) *Navigation.*—Under this head must be understood the conservation of all the navigable portion

of a main stream and its tributaries, and the improvement of the river in this respect when desirable. For this purpose the banks of an open river must at least be retained without deterioration; in most cases they will need improvement. In canalised rivers the whole system of lockage as well as the banks must be kept in good order. In every case, the bottom must be dredged, if the scour is not sufficient to remove the mud that would otherwise accumulate.

(2.) *Sanitation.*—By this must be understood the conservation of the waters of a stream from its source downwards, and of all tributaries, in such a state of purity as shall not injure the health of persons inhabiting the banks of the stream, whether collected in villages or large towns.

(3.) *Fisheries.*—To a certain extent this is concurrent with sanitation; but it becomes a separate subject, and one of primary importance, when the natural food-supply is large and valuable, and there is but a small population of any kind on the banks of the stream, and no urban population whatever.

(4.) *Prevention of Flooding.*—This interest, which in certain rivers and tributaries is paramount, requires close attention to the banks of the stream throughout, the construction of works, perhaps in the upper part of the stream, perhaps near the point where flooding usually takes place, and the maintenance of such works as exist. Where flooding is occasionally inevitable, owing to the physical conditions of the whole catchment area, provision requires to be made to direct the flood, so that it will do as little damage as possible to towns and other inhabited places on the river course.

(5.) *Treatment of Fen-lands.*—In the case of certain rivers which flow over wide tracts of low-lying lands near the mouth, and reach the sea at a level little above low water, the rivers are, in many cases, tortuous, and have no fall for a long distance. To assist the flow by shortening the river channel, and, where necessary, lift the water to a higher level to enable it to reach the sea, have involved the construction of great engineering works, which it is the duty of river Conservators to superintend and keep in order. On the performance of these duties depends the safety of large populations, and the preservation of extensive tracts of land in a cultivable state.

But to carry out properly the systems of drainage in these cases, requires constant attention to the upper parts of the stream and its tributaries, which also becomes the duty of Conservators.

(6.) *Water-power.*—In most streams, the water-power of rivers is utilised in some parts of its course, and the interests of the mill-owners, as well as the rights of the public, where the power is still unused, should be the subject of careful consideration in river conservancy.

Such being the requirements of well-known and important rivers in reference to conservancy, it will be evident that, whatever the districts may be that are ultimately decided on, there will need, on the part of the public officials appointed, much special and technical knowledge, in addition to the general intelligence they may be presumed to possess, and this special knowledge must have a tolerably wide range.

It is quite conceivable that, if the Conservators of a district should be persons chiefly interested in navigation, the sanitation might suffer, or that too absolute a devotion to the sanitation or the fisheries, might result in serious obstruction to navigation. So, also, the measures taken to prevent flooding at certain important points. might interfere with the ultimate delivery of the water from the uplands to the sea, especially in tidal streams, or too rapid a delivery of the waters of a river into a wide extent of flat lands near its mouth, might swamp and injure lands brought and kept under cultivation at great cost.

There cannot be a doubt, also, that rapid and thorough deep drainage of the whole of a catchment area, carrying off the rain quickly to the valleys, and thence to the main stream will not only sensibly alter the whole conditions of agriculture and pasturage, but affect the quantity of water delivered by streams, the times at which the water of feeders is delivered into the main stream and the quality of the water. River conservancy is needed to regulate these results.

In addition to these possibilities, it may be observed that embankments constructed near the outflow of rivers are liable to impede the progress of fish up stream at spawning time, unless care is taken to assist them by mechanical contrivances, to overcome these obstacles.

The constitution of a Conservancy Board for rivers will, therefore, be imperfect, and the Board will be unable to perform its task with intelligence and usefulness, if its members consist exclusively of persons whose monetary interest in land within the district conserved, or in house or other property on the river banks, is their only or chief qualification.

Such persons, however intelligent, could hardly be expected to decide fairly as to the nature and cost of works it might be desirable to undertake, the bearing of such works on those of similar nature already completed, or their influence, perhaps remote, but none the less certain or important, on the future state of the river. The composition of Boards of Conservancy is a matter of great national importance, and requires the introduction of some element other than mere property.

The Conservators of each river basin, or group of catchments, united under one Board, will have special duties, according to the physical condition of the district taken in hand. In each ease, some one or more interests will be paramount, and to these the others must, to some extent give way, but they must not be neglected.

One of the first necessities in every district placed under the control of a Board, will be the construction of a contour map of the whole basin. Such a map has been prepared by the Ordnance Survey for the Thames basin, and it is believed that the facts ascertained by the Survey are sufficient to provide a similar map for every district. A careful study of such a map will be the best introduction to the duties of each Board.

It is desirable that the employment of rivers for any special purpose should not interfere with the proper and legitimate use of the stream for other purposes. All the dwellers on the shores of a river, as well as all riparian owners, have an inalienable right to receive the water that comes down a natural channel, derived from natural sources, in a serviceable and uninjured state, and each person may use it as it passes his property, provided it is

returned to the stream. This right cannot be got rid of without the interference of Parliament, and to enforce the law in this, and secure justice to all who are interested, the action of some public body is necessary, for it is generally the case of the poor against the wealthy and powerful. The conservators of a river system or district should be instructed to regard the preservation of public and private rights as a sacred duty, and should be empowered to act on behalf of the public.

It may, and does happen, that the rainfall naturally falling on the catchment area of a river system may, in part, or even entirely, be better employed, so far as the whole nation is concerned, in providing a water supply for one or more large towns, than for the dwellers on the banks, or the riparian owners. If it is so, the private right must give way to the public need, although in such case full compensation should be given. If only a part of the water is taken, and the water is chiefly employed as motive power, artificial reservoirs may be constructed, the storm waters otherwise running to waste may be impounded, and water compensation given by sending down the stream daily a fair average of the water. In other cases, money compensation may be given. In discussing and settling disputed questions of this kind, an efficient Board of Conservators might, with advantage, give a decision, and prevent litigation.

There are instances in which the channel of a river or tributary has been used for many years as a drain or common sewer, to carry away the waste of manufacturers, and there are other cases in which the water of streams has been fouled by washing or cleansing operations necessary for carrying on important works. When the waters thus injured are feeders of streams which afterwards pass towns and other inhabited places, it may be necessary to prohibit such uses of the water; but great judgment is needed in so doing, for it may be possible to check and divert important sources of national wealth, by interfering with, and rendering unprofitable, staple manufactures in districts in which they have been long carried on.

For purposes of navigation in a river, it has already been mentioned that the removal of accumulations of mud from the bottom is essential, such accumulations being in most cases inevitable. The removal must be effected by dredging, but the selection of a place for the deposit of what is thus removed may need careful consideration.

It may be utilised in the formation of banks, or for raising banks already in existence, and may thus prevent flood; or it may be required to raise permanently the level of the valley in certain parts, or raise adjacent low-lands liable to flooding. On the other hand, it may be desirable to leave certain low lands of little value unprotected, so as to permit flood waters to enter and remain for a time, and thus avoid serious inundation in other parts of the stream. To decide on such matters should be among the duties of the Board of Conservancy.

The duties of conservators in regard to sanitation are very serious. Theoretically, and according to the belief of some authorities, every objectionable material allowed to enter any part of a stream, renders all the waters below suspicious. Practically, we know that no river in existence could be other than a mass of poisonous corruption if this were true, and that, on the contrary, almost all streams, except where the quantity of water is small and the pollution excessive, pass down after a short flow in a clear and apparently pure stream.

There can, however, be no doubt that when manufactures are carried on on a large scale, and where high cultivation and heavy manuring are carried on in lands already deep-drained, a large quantity of polluted matter may pass into the stream. It cannot be denied that this is a source of danger. It might be expected that the large steady increase of population (about two millions in each successive ten years for many decades past) should act in the same direction, and cause increased pollution, but this is counteracted by the tendency of the population to increase in the towns at a rate higher than that of the natural ratio of increase of the whole population, and also by the fact that the precautions now generally insisted on will probably ensure the purification of effluent sewage waters coming from towns. It should be the duty of river conservators to decide what is safe and sufficient purification of this sewage effluent, and take care that no injury to health shall befal any river under their superintendence by neglect of proper precautions.

It has been pointed out that the question of sanitation must in one sense include that of fisheries. If the waters of a stream are fit for human use, they will not be improved for the benefit of the fishes; and, on the other hand, where fish live and multiply, the water is not likely to be in a very unfit state for men. Many rivers and tributaries, however, coming from the hills in a state of extreme purity, and crowded with fishes, receive at certain points the waste of, or are otherwise fouled by, manufactures which destroy the fish. Where the volume of water is increased by large additions in a pure state, and the matter thrown in is not deleterious, or is purified by oxidation on its way to the main stream or the sea, or when the stream is small and passes no town or place where its waters are needed for domestic purposes, it may be a question whether the manufacture is to be sacrificed to the fisheries. In deciding this question, which is one certain to come before them, Conservancy Boards will need to exercise great judgment.

To prevent a river, when in heavy flood, from so expanding at certain points of its course, as to avoid injury to towns or important manufacturing or other interests near its banks, has always been regarded as one of the chief objects of river conservancy, and is so recognised in the Act now before Parliament. The injury from flooding is not only very serious as regards property, but it extends to human life, and, if possible, should be prevented at any cost. The works, however, that must be constructed to check this mischief require great engineering skill to plan; they require that the whole history of the river and each tributary should be carefully studied, and that the meteorology and geology of the whole catchment should be as well known as the physical geography. In the Thames basin, where the interests are largest, the construction of the basin renders this reference to the whole

physical condition more necessary than in any other in England; but in almost every division of the country that could be suggested, complications are sure to arise, with reference to the times, places, and possible amount of flooding, that need constant attention to these physical conditions. It is not desirable that any Board of Conservators should be appointed without members qualified to recognise the importance of considerations of this kind.

Boards of river conservancy appointed to manage the Great Ouse, the Welland, the Nen, and the Witham, draining the Fen country, and emptying into the Wash, have to deal with a tract involving special and recognised difficulties, and provided already with numerous engineering works, which have been constructed, or in course of construction, during a long period, and are provided with engineers to carry out the requisite operations. The duties of the conservators, however, in this and other cases of special kind, should extend over the whole of the river basins concerned, and enable them to watch over and influence the outfall by controlling the rivers from their sources. There can be little doubt that in this way much might be done to diminish the risk that sometimes arises in very wet seasons.

With regard to the large tracts affected by this group of rivers, and others that enter the sea over similar fen lands, it is well known that their inhabitants are liable to fever, ague, and rheumatism. It is no doubt true that these special diseases of fen districts have been checked and modified by improvements in drainage, but there is still much to be done in this respect, and it can only be done by combined action over large districts, and with the aid of constituted authorities.

The remarks I have ventured to offer on the duties of river conservators I wish to be regarded as suggestions for discussion, rather than as an attempt to embrace the whole subject. It has occurred to me that, in the preparation of the Bill now before Parliament, both the powers to be granted, and the duties to be performed, by the Boards have been insufficiently considered, and that, under these circumstances, a discussion as to these matters might bear useful fruit. It may not be too late now to introduce clauses into the Bill in Committee, and should this Bill not pass during the Session, the way will thus be opened for a more complete and better-considered measure hereafter. It is not likely that our rivers and river basins will continue to be neglected as they have hitherto been.

The conservancy of rivers very directly affects the question of water supply to towns. That rivers must always be, as they have always been, the most valuable sources of supply for general purposes is inevitable, and that in many cases due care has not been taken to preserve them from pollution is equally certain. In such cases, instead of sources of health they may become the means of introducing disease. Under the care of properly-selected conservators, empowered to act, and required to enforce the law against all who infringe it, there is no reason why every river in the kingdom should not be utilised in a reasonable way for power for manufacturers, and for the use of towns, and after all this be sent down to the sea in such a state as to do no harm to the human inhabitants on the banks, or to any fishery that the density of the human population will allow to exist near its outfall.

SUPPLY AND STORAGE OF PURE DRINKING WATER, EAST BRENT, SOMERSET.

By the Ven. Archdeacon G. A. Denison.

I have much pleasure in complying with your request, that I should send you some brief account of what has been done for storage and supply of pure drinking water at East Brent, lying at the foot of Brent Knoll, Somerset.

Twelve years ago there was no such supply, except to a very limited extent, for the village of East Brent, with its large vicarage house. The sources of such supply were also at a considerable distance from the houses. Now, the water rises by natural pressure to the top of the vicarage house, and is brought within a little distance from every house in the village, in some cases into houses by branch pipes. The supply is also unfailing and overflowing. I have been nearly 34 years at East Brent. There had been always water for the vicarage house, but with supply failing in very dry weather, and only at command by means of a force pump.

In the 34 years there have been three years of epidemic disease. I found that in all three cases, the disease came in years of drought, and after drought. The reason of this is simple. The inhabitants generally draw their water from the same ditches which carry the sewage. In time of drought the amount of sewage bore a proportion to the water running or standing in them so large as to poison the whole of it; whereas, in time of larger fall of rain, the poisonous effect was, so to speak, neutralised.

All these things, and indications of a choked spring a little way up the knoll, led me to begin the experiment of spring tracing and reservoir making. The result has been the discovery of the old mill of Glastonbury time, and, as I believe, of hundreds of years before 1180, the present date ascertained; two springs of excellent water, never failing, and of the formation of several reservoirs containing together a large supply of mixed spring and surface water. It is to be noted that, as there are no houses on the knoll, the supply of surface water, at times very large indeed, is as pure as can be had. But the two springs being more than sufficient for the use of vicarage house and village, I am drawing all supply from them, shutting off the reservoir water, which in a rainfall, becomes clouded for some days, and insuring a constant supply of pure and unclouded water. I have, however, reserved command over the reservoir water, in case that, in excessive drought, the springs should fall too low. The reservoirs fall at varying heights, the higher into the lower, by overflow or tap, or syphon; the entire fall from the upper end, of the highest reservoir, to the door of the vicarage house, being some 50 feet. They make excellent pools for trout and other fish.

Having thus been enabled to supply the vicarage house and village of East Brent, I am very desirous, if the means can be provided, of

supplying, out of the great quantity of water, which might be had by further means of storage, and developing of springs, the villages round the knoll, and first of all, a hamlet of my own parish, about 1½ miles away. That this might easily be done, and at a cost which, relatively to the benefit to be insured, would be very small, it is impossible for me, with all my experience of the locality, to doubt. But it is a thing quite beyond my own means, and one which ought to be taken in hand publicly. At present, the district is in the position of having abundance of pure water offered to its hand, but of refusing to stretch out its hand to take it. The knoll is a great natural reservoir. It presents great natural advantages for storage of surface water. It is full of springs. All that is wanted is to develop and apply. As the matter now is, I know of no worse instance of neglect of a great natural gift.

I shall be happy to receive at East Brent any one interested in supply of water, and to show him what has been done, and how much more might be done.

Since writing the above, I have received this morning, May 10th, from an able analyst the report following:—"Both your springs are remarkably free from organic impurity, and admirably adapted to drinking uses."

MISCELLANEOUS.

ELEMENTARY SCIENTIFIC EDUCATION.

In the House of Commons, on the 30th July last, **Sir John Lubbock** brought forward the question of teaching science in elementary schools. He urged that elementary science should be placed on a par in the Education Code with grammar, geography, and history. The suggestion since he last made it had been gradually gaining adherents, including no less an authority than the London School Board. He might remind the House that the committee which sat on Elementary Education in 1868 and the Royal Commission on Scientific Instruction strongly recommended that elementary science should form a part of the national school system. Several of her Majesty's inspectors of schools were also of the same opinion, and he could quote in favour of his views the almost unanimous voice of those who had devoted themselves most successfully to the education of the people—such men as Dean Dawes, Mr. Henslow, Mr. Ellis, and Sir James Kay-Shuttleworth. Lastly, he might refer to those whom, in this matter, he regarded as, perhaps, the highest authorities of all—namely, the children themselves. Wherever elementary science was taught, they welcomed it with a warm interest. He did not seek to impose any new duty on the Department or on schools, but only to leave them an option. The practical difficulties in the way could be easily overcome, and his proposal, so far from upsetting the equilibrium of the code, would, for the first time, establish it, seeing that, at present, the code was entirely one-sided, all knowledge of natural phenomena being excluded. He admitted that it would not be desirable to impose new duties on school managers or committees, but he did not propose to do so. Quite the contrary; his wish was to remove an objectionable restriction. His proposal would, therefore, not make the code more complex, but the reverse. The present system crammed the heads of the children, and overtaxed their memories. A string of verbs, or dates, or names of kings was a mere matter of recollection. He wished, on the contrary, that a portion of the school time should be devoted to explanations of the common phenomena of nature, which experience showed had a strong interest for children. It was often said that it was ridiculous to teach "ologies" before the children could read and write thoroughly. But, in the first place, it was a misnomer to call the lessons he proposed "ologies;" secondly, it should be remembered that, when children were learning to read, they had to read something, and the question was what that something was to be. The real difficulty was that we had no good old Saxon word in use among us for "natural science." If we had any expression equivalent to the German word *Naturkunde*, he believed that the House would unanimously adopt the present resolution. He was, however, compelled to use the word "science," though, unfortunately, he immediately frightened hon. and right hon. gentlemen opposite. Contrary to what was believed in some quarters, his proposal would really not involve any appreciable cost. The little books would come to no more than those on history or grammar; while the sun, moon, and stars, rain and dew, wind and light, air and water, heat and cold, stones and flowers were before us all; and even if a few objects as illustrations were required, they could be obtained for a few shillings. He wished for nothing difficult or abstruse, nothing beyond the range of the children's minds and daily experience. In mechanics, the simple forces might be explained to them—why carts were put on wheels, how levers and pulleys acted, the use of the screw and wedge; then the nature and relative distances of the principal heavenly bodies, the primary facts relating to air and water in agricultural districts, the character of the soil, the reason for the rotation of crops, the origin and principal qualities of such substances as chalk, coal, iron, copper, &c.; the succession of the seasons, the flow of rivers, the growth of plants; the fundamental rules of health, the necessity for ventilation and cleanliness, and, last, not least, the need for industry, frugality, and economy. Explanations of these simple and every-day things would be most interesting and useful to the children. So far from cramming and confusing them, you would introduce light and order into their minds, and give them an interest in their lessons, which, under the present system, they rarely felt. So much for the educational side; but, before sitting down, he wished to say one word with reference to the amendment from the point of view of local self-government. Much of our freedom and success in Parliamentary government was due to the training afforded by our municipal and other local institutions, and he confessed that he viewed with some apprehension the present tendency to centralisation. He was not asking that any new duty should be imposed on localities, but only that they should have a power, which, practically, they possessed until the last few years, and which the Education Department had every year reported to have been exercised with discretion. In the interest of local self-government, in the interest of education—nay, more, in the name of the children—he appealed to the House to support the amendment which he now begged to move, namely, "That it would be desirable to modify the Code of Education by adding elementary science to the subjects mentioned in Article 19, c. 1."

Lord E. Fitzmaurice had for some time on the paper a notice to call attention to the number of examinations which the pupil-teachers and students of the training colleges had to pass, and of the desirability of establishing a series of higher standards in night schools. It might not appear at first sight what the connection was between those subjects and his hon. friend's motion, but if that motion were adopted it would become obligatory, instead of permissive, for all elementary teachers to have passed an examination in natural science, and all school managers would

require that the teachers should be competent to teach natural science. That would be a great addition to the already heavy burden placed on the shoulders of pupil-teachers and colleges. There had within the last 15 years been a steady, a constant, and an enormous increase in those burdens. The following subjects were practically compulsory upon students during their first and second years in the training colleges, learning by heart, reading, penmanship, school management, grammar, composition, geography, history, arithmetic, algebra, mensuration, geometry, political economy, and, he supposed to cheer those whom the teaching of political economy had made dull, vocal music. There were, in addition, elementary classics and science, which were not strictly obligatory, but the inducements held out to take up one or the other might be regarded as rendering it a matter of compulsion. He asked the House whether if his hon. friend's motion were adopted there would not be, so to say, a further tightening of the girths. In fact, natural science would become a strictly obligatory subject of examination. What they should look for, in his opinion, was not so much the teaching of science as for what used to be called object lessons. There were two points he desired to press on behalf of the unfortunate pupil-teachers and students to whom he had referred. He did not think the Education Department sufficiently appreciated the great difficulties under which knowledge had to be acquired by the children of the labouring classes of this country. The House was not now drawing up a merely abstract code which they would wish to see complied with. They were dealing with girls and boys, women and men, and they ought to bear in mind the class of life from which they were drawn before they placed upon them additional burdens. A pupil-teacher or student from the time he became such until his leaving the training college had to pass no fewer than eight examinations, and there was no break in their continuity. No sooner had they passed one examination than they had to prepare for another. At the University of Cambridge examinations were held at considerable intervals, and no one was worried by them. Then, again, in subjects to which they were now asked to make an important addition, the standard required was absurdly high. The standard, for instance, in the case of high mathematics required in a pupil-teacher last year at the training college was positively higher than was required for the ordinary Bachelor of Arts degree at Cambridge. His noble friend would, he trusted, inform the permanent officials of his Department that the opinion of many persons whom he (Lord E. Fitzmaurice) could name, to whom he had spoken and who were capable judges of the matter, was that the state of things to which he had directed the notice of the House was absurd and ridiculous. He believed that his noble friend had already lightened the load of the unhappy pupil-teachers so far as regarded the extent to which they were required to learn poetry and prose by heart, and he hoped he would go further in the same direction as regarded other subjects, and would transfer the higher mathematics from the obligatory to the voluntary column. Then with respect to night schools, he was strongly of opinion that in these a series of higher standards should be established. When boys had passed through the ordinary course of education they ought to be encouraged to attend night schools, and there to continue and improve their education. A committee of the London School Board had been or was about to be appointed to consider this subject, and he was informed that the system he had recommended had been at work for some time in Glasgow and with the best results. He had brought forward the first subject to which he had referred, because of th impression made upon him last winter by cases with which he became acquainted in which the cruelty of the existing system of examination had caused a break down, not only of physical health, but, worse still, of mental capacity.

Mr. Beresford Hope said the comparison which had been made between the standard of mathematical teaching in the University and the standard of mathematical teaching in training colleges was pregnant with meaning. The great evil in our educational movement was a confusion of means and ends. Surely, the objects of any training college should be to produce instruments, not only capable, but willing readily and cheerfully to discharge the useful, though perhaps humble, service of training the children of the labouring classes satisfactorily to perform their duties in life. The present system resulted frequently in the production of an unknown genius—a philosopher masquerading as a village schoolmaster. They might be certain that a man who was very learned in the higher branches of mathematics would not make a good teacher of the three R's, for, having the power to soar into the nobler regions of the binomial theorem and of quadratic equations, he would despise those rudimentary branches of education. The present system reminded him of that of some magnificent horticulturist, who spent thousands a year upon his vineries and only produced a few show bunches of grapes. With regard to the question of the fairness of giving repetition a place in examinations, he might say that when he was at Harrow the idea of reciting from memory at an examination was never dreamt of. A desperate attempt was indeed made at one time at that school to galvanise the system of repetition into life by awarding prizes for proficiency in it, but the attempt, even in these circumstances, was not successful. In short, repetition could never be a true standard of examination. With regard to the suggestion that had been made as to the expediency of raising the standard of teaching in night schools, he wished to point out that if the alternative subjects that had been named were admitted into a school of the kind, its manager would never engage a master who was not competent to conduct the night department with its enlarged curriculum.

Dr. Playfair said that he should not travel beyond this issue—namely, whether elementary science should or should not be constituted an optional subject in connexion with our ordinary school education. It seemed to be thought by some hon. members that if the amendment before the House were passed, teachers in training schools would be obliged to learn the subjects of natural science. This he desired to say was a misconception. Should they, then, allow teachers who had been taught natural science as an optional subject to impart instruction in the ordinary phenomena which were continually presented to children? Should not children, he asked, be taught something respecting the air they breathed, the water they drank, and the food they ate? The difficulty in the way of providing this knowledge would not be found to come from the teachers, who generally knew enough of elementary science, but from her Majesty's inspectors of schools, who for the most part had not acquired an elementary knowledge of science, and who consequently disliked the subject. If these inspectors had been taught at the Universities the subjects coming under the head of natural science, they would see that such knowledge was most suitable for children. Of what use was it to spend a long time in teaching children in mining districts grammar? Would it not be of greater importance to teach them about the dangers they would have to meet in their calling—about fire damp and after damp, for instance? In the same way should not a child destined to become an agricultural labourer be taught something about the earth, the properties of manure, and other subjects connected with cultivation? The request of the hon. member for Maidstone, who asked neither for compulsion nor expenditure, was such a simple one that he could not help hoping the Govern-

ment would refrain from opposing it. The time had undoubtedly come when it was desirable to spread such useful knowledge as that which he had indicated, and he therefore trusted that the proposal of his hon. friend would be carried out with no more delay than was unavoidable.

Lord G. Hamilton said that when the hon. baronet brought forward his proposal last year he stated that the Education Office would be most anxious to consider the views of the hon. member, and would see whether the practical difficulties standing in the way of the proposal could be overcome. Since he had so answered the hon. baronet he had communicated with a number of gentlemen on the subject before the House, and he would now acquaint the House with the result of those communications. The concluding part of the speech of the hon. baronet was, he contended, a little misleading. The hon. baronet made an appeal to the House on behalf of local government, asking that the different localities might have some option with regard to the subjects to be taught in their schools, and concluded by saying that the great branch of human knowledge to which he was drawing attention was excluded from the school curriculum. This, however, was not a perfectly correct statement of the case, as there existed nothing to prevent a competent teacher from giving instruction in science to the children under him. But a teacher was not necessarily paid for giving such instruction, and the object of the hon. baronet was that he should be paid. It was clear that the object of the hon. baronet was to bring in the elements of natural science. The first objection to that was, they could define natural science so that the teacher should know what to teach and the inspector what to examine? Natural science, as he stated last year, included every branch of human knowledge except literature and moral philosophy. There was a large number of excellent teachers who obtained certificates, and if any of these teachers happened to be out of a place he or she would be asked, "Can you teach elementary science?" That would be the first question, and it would be pointed out that the Education Department had laid down the rule. In such a case it would be found that a considerable obstacle would be put in the way of a most excellent teacher obtaining employment. Since last year the Department had had this matter constantly under their consideration, and he said unhesitatingly—although a considerable number of eminent persons' opinions might be quoted in favour of the resolution—the balance of opinion was against it. This was more true of the teachers than even of the inspectors. Dr. Gladstone, a prominent member of the London School Board, had given much attention to this subject, and last year he delivered a lecture at the Society of Arts, of which a copy had been sent to him (Lord G. Hamilton). Dr. Gladstone had been asked to make out a course, and that course had been sent in; but Dr. Gladstone said that, although it might be suitable for the London School Board schools, he should not take the responsibility for prescribing for the schools in the country. There then was another difficulty. They were told that in Germany this class of instruction was given to the children, but there the system of instruction was quite different. The Education Department had altogether abandoned the practice of prescribing a text-book. He agreed with the right hon. member who had just spoken that the best way to meet this difficulty would be that the managers of different schools should take particular care as to the particular text-books used as reading-books in the schools. So in the mining districts, the manager of a school would take the trouble to obtain such a text-book as would impart the various information referred to by the right hon. gentleman. But this was information which they would get in the ordinary reading lessons. As to this point, he could only refer to what he said last year. It was said that only 5,000 children had passed in science, but the number was 45,000 in specific scientific subjects, and the number would have been greater only that children were not allowed to compete until after they had passed the fourth standard. The member for Lanarkshire rather complained that the Education Department had ousted the older subjects and given preference to scientific subjects, but it was satisfactory to learn that, so far from the country schools not holding their own in classical examinations, they had succeeded in beating children from the town schools. In Latin and Greek the children in the country schools had passed better than the children in towns. Then his noble friend asked that opportunities should be given to those attending night schools to pass in the higher standard and receive instruction in science and other subjects. The night schools were rather excrescences, so to speak, upon the education system, and, with the small number of attendances, it was impossible to pass in the higher standards. No doubt, in many cases, the opportunities were availed of, and at the present moment he should not like to give a definite answer on the point. On the whole, he could not see his way to accepting the motion, which he did not think could be carried into practical effect.

Mr. W. E. Forster said although the noble lord was unable to accept the motion of his hon. friend, yet it would be found the more the subject was looked at the less the difficulties would become. He had listened attentively to the statement of the noble lord, and he did not believe the real objection to the motion had been stated. The real objection was the difficulty of the office in defining these lessons. He believed his hon. friend had hit the difficulty—namely, that the inspectors were more ignorant of science than anything else. Many of the members of that House felt that they had not been properly taught elementary science. He did not think there was any insuperable difficulty in the way of the proposal, but he would hardly advise his hon. friend to go to a division. The reason why he should not recommend that course was that he wanted the Department to consider the matter for another year. He did not suppose that in the case of girls the teaching of science would interfere with needlework; what would happen would be this, that, for boys, science and history would be taken instead of grammar and history, or science and grammar in the place of grammar and geography. He had a great liking for the study of history and geography, but he did not think it was more necessary than scientific knowledge. One subject would be taken out and the other inserted. He did not see why, when managers and teachers wished that this most useful and practical subject should be taught, the Department should interfere and say, "We won't let you have your way." He would conclude by making this suggestion—that the Department should find out, between now and next Session, how this was done in Germany, and should tell the inspectors that they must acquire a little elementary science, in order that they might be able to conduct examinations in natural science.

The House then divided, when there appeared—For Sir J. Lubbock's amendment, 48; against it, 80; majority, 32. The amendment was, therefore, lost.

A Congress connected with the International Society for the Amelioration of the Condition of the Blind, founded at Paris in 1878, has just been held at Berlin, at which a German Section was formed under the patronage of the Government. The Council of the Society of Arts have appointed a committee to co-operate with the International Society, who propose to hold their next Universal Congress in London.

It is stated that there is a probability that the Consett Iron Company will take up the manufacture of steel with the Gilchrist-Thomas lining.

UTILISATION OF THE WASTE FUEL OF LOCOMOTIVES.*

The engineer of the Eastern Railway of France lately turned his attention to discover some means for utilising the small cinders drawn by the blast through the flue tubes of locomotives, and deposited in the smoke box, which had, until then, only caused trouble and expense to the company. The proportion of these small cinders was found to vary between 1 and 10 per cent. of the fuel originally burnt, increasing with small and poor coal, and also when the engine works nearly up to the limits of its power. Experiments showed that the cinders contained from $1\frac{1}{2}$ to $5\frac{1}{2}$ per cent. of volatile matter; more than 22 per ceut. of ash was present, but the large grains contained less than the smaller. The quantity of ash was also greater in winter than in summer; but, even under the most unfavourable circumstances, the proportion might be reduced to 18 per ceut. on extracting 60 per cent. of the total amount of refuse by dry sifting.

With the addition of from 8 to 10 per cent. of gas-works pitch, the proportion of ash in the mixture would be reduced to a maximum of $16\frac{1}{2}$ per cent., no greater than the amount usually contained in unscreened coal of inferior quality, as usually employed for firing stationary boilers.

The conditions of the experiment were, that the conglomeration of the waste cinders should be effected with the simplest and most inexpensive apparatus possible; and the products were to be available for use on the fire-grates of the running shed and stationary boilers. The grains, freed from dust and ash by screens with holes of two millimetres (0·079 inch) diameter, were, with the addition of 10 per cent. of roughly broken pitch, put into a Carr's disintegrator making 400 revolutions a minute, and, when sufficiently mixed, passed into a pug-mill heated with a jet of steam. The mill, making from 15 to 18 revolutions a minute, converted the mixture into a paste, which was thrown by the shovel into the distributor of a Dupuy brick machine, altered for its new duty under the direction of the engineer. This machine, which is simple, cheap, and portable, produced from 14 to 15 *briquettes*, weighing about three kilogrammes ($6\frac{1}{2}$ lb.) each, per minute, or 30 tons a day.

The degree of cohesion of the *briquettes* made in the Eastern Railway Company's coal depôt, La Villette, Paris, was fouud to be from 56 to 57 per cent., which was deemed satisfactory, as the French Marine Department, whose method of testing was adopted, only requires a cohesion of 50 per cent.

With a four horse-power portable engine, supplemented by an old locomotive boiler—the only motive power employed at La Villette—it was not possible to perform the operatious of riddling, grinding, pugging, mixing, and compressing all together; but this circumstance, though the reverse of economical, permitted of ascertaining the amount of power required by each. The compressor absorbed 5 h.-p., the mixer from 3 to 4, according to the temperature, and the screen and disintegrator 7 to 8. With a series of machines properly arranged for the manufacture, the cost is estimated by the engineer as follows:—Labour, per day, for producing 25 tons of *briquettes*, 36 fr., or 1 fr. 44 c. per ton. Add to to this 85 kilogrammes (187 lb.) of pitch, at 58 fr. a ton, 4 fr. 93 c., and fuel for the engine, grease, and waste, 22 fr. a day, or 0 fr. 88 c. per ton, with 50 c. per ton for wheeling the cinders up to the machines, aud the cost of manufacture is 7 fr. 75 e. per ton. A margin of 2 fr. 25 c. for mainteuance, interest on capital, and general expenses, brings up tho total cost to 10 fr. (8s.) per ton, showing a saving of 7 fr. (5s. 10d.) on the price of small coal that had until then been used for the same purposes for which *briquettes*, made from the waste fuel of locomotives, are now employed.

Since the above report was published, the same machine has been turning out *briquettes* for a new branch of the French States Railways, at the rate of 4 fr. 40 c., or 3s. 6d., a ton, including all expenses.

* From a report by M. A. Gambaro, superintendent, Fuel Department, Eastern Railway of France, in *La Revue Generale des Chemins de Fer*, Dunot, Paris.

RAILWAY ACROSS THE SAHARA.

Mons. de Freycinet, Minister of Public Works, lately presented to the President of the French Republic the report of the committee appointed to consider Mons. Dapouchel's project for uniting Algeria with the Niger by an unbroken line of railroad 1,250 miles in length. The general statement of the committee was to the effect, 1st, that there exists in Soudan a large population, a fertile soil, and natural riches which are uncultivated. It is very important to open outlets for commerce through the French possessions, which are the most favourably situated for this purpose. France ought to follow the example of England, and do her best to induce the caravans to cross French territory instead of only coming to its borders. 2nd. The opening of a railway joining our possessions in Algeria with Soudan is necessary in order to obtain this double result. 3rd. It is also necessary to join Senegal with the Niger. 4th. The explorations or surveys of the undertaking ought to be directed simultaneously from Senegal and from Algeria, and the plans ought to include both direetions. 5th. South of Algeria, the uncertainty which exists regarding the topography, the climate, the resources, and the inhabitants of certain parts of the Sahara, make it necessary to proceed with care in order to avoid mistakes and military complications. 6th. It will be advantageous to start immediately with a preliminary line between Biskra and Ouargla of about 200 miles. This line ean be joined by the Hodua to the line from Algiers to Constantine. As far as Ouargla ordinary escorts appear sufficient to protect all operations. 8th. A credit of £800 will be demanded to meet the expenses of the surveys, and the needs of the explorers.

While the committee have been eonsidering the matter referred to them, eommittees of the Chambers of Deputies and the Senate have expressed decided opinions on the need of immediate action in regard to the opening of railways iu Northern Africa. The Commission of the Senate on the Railroads of Algeria haue reported as follows:—"The committee unanimously agree to the surveys which are necessary for the execution of the railroad across the Sahara; they are certainly convinced that it is greatly to the interests and to the advantage of our country for us to solve this problem of the basiu of the Niger, and to be in advance regarding the civilisation of those countries which our colony of Algeria opens to us."

At the suggestion of M. de Freycinet, the President of the Republic has appointed a Commission, with power to cause surveys to be made, and to institute such exploring expeditions as are found to be necessary to decide as to the practicability of constructing the proposed railroad. Those interested in the scheme are of opinion that the Sahara itself will not form so serious an obstacle as has been supposed, and that it will be possible to obtain water by sinking wells in many parts of the desert districts.

The new steamer *Arizona*, which passed Sandy Hook at half past-five, June 17th, arrived at Queenstown at twenty minutes past seven on the morning of June 25th. The actual running time was 7 days 9 hours and 23 minutes, which is the fastest transatlantic trip on record. This is $1\frac{1}{2}$ hours less than the time of the *Britannic*, in August, 1877.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

TECHNOLOGICAL EXAMINATIONS.

These Examinations having been handed over by the Society, to the City and Guilds of London Institute for the Advancement of Technical Education, are now carried on by that body, and the following list gives the results of the Examinations for the present year.

The following candidates have obtained certificates. The letters H., A., and E., represent the Honours, Advanced, and Elementary grades respectively, and the figures which follow denote the class in each grade. The numbers after the names show the ages of the candidates.

Alkali Manufacture.

Edwards, Harry L., 21, Liverpool Inst., E. 2
Gleave, William, 20, St. Helen's Sci. Class, E. 1
Houghton, John F., 18, St. Helen's Sci. Class, E. 2
Hunt, Joseph S., 23, Widnes Sci. Class, E. 1
Kay, Andrew, 21, St. Helen's Sci. Class, E. 2
Latham, John J., 18, Widnes Sci. Class, E. 1, with the Prize of £5
Oakden, William E., 22, Widnes Sci. Class, E. 1
Snape, Henry L., 18, Liverpool Inst., E. 2
Taylor, James, 28, Widnes Sci. Class, A. 1, with the Prize of £7
Yearsley, Robert J., 26, Widnes Sci. Class, E. 2

Blowpipe Analysis.

Barnett, Andrew K., Redruth, E. 1, and a Prize Blowpipe
James, William H., Redruth, A. 1, with a Prize of £2
Johns, John H., Redruth, E. 1
Johnson, Frank, A 2, and a Prize Blowpipe
Ormsby, Charles C., Redruth, A. 2, and a Prize Blowpipe
Provis, Richard, Redruth, A. 2, and a Prize Blowpipe
Rich, Thomas, Redruth, A. 2, and a Prize Blowpipo

Cotton Manufacture.

Armstrong, John, 20, Oldham Sci. Sch., E. 2
Bardsley, George W., 18, Bolton M.I., E. 1
Carr, John, 26, Bolton Parish Church Sch., E. 2
Curwen, Richard, 24, Bolton Parish Church Sch., E. 2
Firth, Walter, 17, Huddersfield M.I., E. 2
Fisher, John, 23, Halifax M.I., E. 2
Hamer, Samuel, 23, Bolton Parish Church Sch., E. 2
Hayes, Thomas, 28, Oldham Sci. Sch., E. 2
Hepworth, Frank, 17, Oldham Sci. Sch., E. 2
Heywood, Tom, 23, Bolton Parish Church Sch., E. 2
Hodson, Charles, 27, Bolton Parish Church Sch., E. 2
Kenworthy, William H., 18, Oldham Sci. Sch., E. 2
Lawson, William, 31, Oldham Sci. Sch., E. 2
Lees, John T., 22, Oldham Sci. Sch., A. 2
Marcroft, John G., 18, Oldham Sci. Sch., E. 2
Morris, John, 28, Bolton Parish Church Sci. Sch., E. 1, with the Prize of £5
Potter, James, 16, Oldham Sci. Sch., E. 2
Scott, Arnold, 19, Blackburn Sci. Sch., E. 1
Waite, James A., 21, Bolton Parish Church Sch., E. 1
Welsby, Walter H., 20, Bolton Parish Church Sch., E. 2
Whitehead, James, 17, Oldham Sci. Sch., E. 1
Witter, Thomas, 28, Bolton Parish Church Sch., E. 2

Gas Manufacture.

Askew, Benjamin, 30, Wedgwood Inst., E. 1
Bell, John F., 22, Liverpool Inst., E. 1
Blair, Thomas, 24, Finsbury, E.C., A. 1, with the Prize of £7
Haddock, William S., 22, Widnes Sci. Class, E. 1
Hepworth, Reuben A., 25, Halifax Mech. Inst., H. 1, with the Prize of £10
Holden, Henry, 17, Oldham Sci. Sch., E. 1
Hornby, John, 21, Widnes Sci. Sch., E. 1
Kay, George W., 26, Oldham Sci. Sch., E. 2
Meiklejohn, Charles, 21, Houghton-le-Spring Sci. Sch., E. 2
Meiklejohn, Neill, 19, Houghton-le-Spring Sci. Sch., E. 1, with the Prize of £5
Plant, Joseph, 35, Wolverton Sci. Sch., E. 2

Steel Manufacture.

Adnitt, Charles G., 21, Crewe M.I., E. 2
Allison, Thomas, 20, Crewe M.I., E. 2
Ambler, Frank, 16, Crewe M.I., E. 1
Andrew, Samuel, 19, Oldham Sci. Sch., E. 2
Bailey, James, 16, Crewe M.I., E. 1
Bailey, John M., 23, Crewe M.I., E. 2
Beaumont, Tom, 21, Crewe M.I., E. 2
Broomer, William, 21, Crewe M.I., E. 1
Chadderton, Frank W., 17, Oldham Sci. Sch., E. 2
Clarke, William, 21, Crewe M.I., E. 2
Cotton, Albert, 20, Crewe M.I., E. 2
Dawson, William, 19, Crewe M.I., E. 1, with the Prize of £5
Dean, James A., 23, Crewe M.I., E. 1
Douglass, Malcolm, 17, Crewe M.I., E. 1
Duckworth, Thomas, 22, Liverpool Inst., A. 2
Duncanson, William, 18, Stratford M.I., E. 1
Eaton, George, 26, Crewe M.I., E. 2
Edwards, Lionel, 22, Crewe M.I., E. 1
Gabriel, Ernest E., 20, Crewe M.I., E. 1
Geddes, John W., 20, Oldham Sci. Sch., H. 1, with the Prize of £10
Gray, George, 18, Crewe M.I., E. 1
Green, William H., 18, Crewe M.I., E. 2
Harrison, George, 20, Oldham Sci. Sch., E. 1
Haylock, Ralph H., 18, Stratford M.I., E. 2
Holland, George, 23, Crewe M.I., E. 1
Hughes, William R., 18, Crewe M.I., E. 2
Jackson, John N., 27, Crewe M.I., E. 1
Kenworthy, Orlando, 19, Oldham Sci. Sch., E. 2
Laird, William D., 22, Crewe M.I., A. 1
Lambeth, John, 20, Crewe M.I., E. 1
Latham, William B., 26, Crewe M.I., A. 1, with the Prize of £7
Mackay, Alexander, 22, Crewe M.I., E. 1
Manion, John, 25, Oldham Sci. Sch., E. 2
Morgan, Thomas H., 22, Crewe M.I., E. 2
Neild, Robert R., 19, Crewe M.I., E. 1
Phelan, James, 28, Crewe M.I., E. 2
Platt, Joseph, 26, Oldham Sci. Sch., E. 2
Routledge, William E., 21, Crewe M.I., A. 2
Sackfield, Thomas E., 20, Crewe M.I., A. 2
Sackfield, William, 17, Crewe M.I., E. 1
Savage, Henry, 23, Crewe M.I., E. 1
Savage, William, 20, Crewe M.I., A. 1
Simons, Charles, 18, Crewe M.I., E. 1
Tobin, James W., 20, Crewe M.I., E. 1

Turner, John, 17, Stratford M.I., E. 1
Widdowson, James D., 18, Crewe M.I., E. 2
Wild, Arthur E., 18, Crewe M.I., A. 2

Wool Dyeing.

Briggs, Frederick W., 20, Huddersfield M.I., E. 1, with the Prize of £5

The following candidates have passed in their Technological subjects, but not having gained the required successes in the Examinations of the Science and Art Department, have not obtained Certificates :—

Alkali Manufacture.

Callander, William S., Widnes
Farrant, Nathaniel, Widnes
Hosker, Richard B., St. Helen's
Upward, William, Widnes

Cotton Manufacture.

Kearsley, Alfred, Oldham

Gas Manufacture.

Carpenter, Samuel, Stratford
High, William R., Science and Art Department, South Kensington

Steel Manufacture.

Barker, Joseph, Crewe
Beresford, Samuel, Crewe
Blake, Edwin L., Oldham
Brawn, George, Crewe
Broughton, Frank, Crewe
Chantrey, Francis D., Crewe
Chester, Arthur H., Crewe
Colley, William, Crewe
Copnall, Stephen, Crewe
Dyer, Joseph, Crewe
Edwards, James H., Crewe
Egerton, James, Crewe
Fleet, William H., Crewe
Godber, Moses, Crewe
Greensmith, Thomas W., Crewe
Herbert, Charles, Oldham
Hobson, Frank, Crewe
Hughes, Henry, Crewe
Hughes, William H., Crewe
Jackson, George F., Crewe
Kenyon, Thomas, Crewe
Laird, Harry, Crewe
Lea, Samuel, Crewe
Latham, Robert H., Crewe
Marsh, George, Crewe
Milner, Henry, Oldham
Nevitt, Henry, Crewe
Nichols, Thomas, Crewe
Palmer, Alfred, Crewe
Penny, William T., Crewe
Phelan, William, Crewe
Power, Thomas, Crewe
Sinclair, Robert, Crewe
Stubbs, John, Crewe
Vernon, Joseph, Crewe
Wadsworth, William H., Crewe
White, James, Crewe
Worthington, John T., Crewe

Telegraphy.

Coates, Alfred S., Telegraphists' School of Science
Field, Henry A., ,, ,,
Pink, Ernest G., ,, ,,
Sayers, Henry M., ,, ,,
Thompson, Arthur W., Halifax

Wool Dyeing.

Aldred, James, Oldham.
Dyson, Henry, Halifax
Wadsworth, Clarence, Oldham

GROSVENOR HOUSE.

The Duke of Westminster is desirous that designers, artisans, and the like, employed in any branch of Art applied to productive industry, should have the opportunity of inspecting Grosvenor House, with its Works of Art, daily, including Sundays, during the months of August and September, 1879, from 2 p.m. to 6 p.m. He regrets that, for want of room, he cannot extend the admission beyond the persons specified.

A number of tickets of admission have been placed in the hands of the Secretary of the Society, for distribution among persons answering to the above description.

Such persons can obtain tickets on application at the Society's house, by bringing with them a paper containing their names, addresses, and occupations.

Each ticket admits a party of four.

There will be no admission on wet afternoons.

CANTOR LECTURES.

DWELLING-HOUSES: THEIR SANITARY CONSTRUCTION AND ARRANGEMENTS.

By Prof. W. H. Corfield, M.A. M.D. (Oxon).

Lecture V.—Delivered March 17th.

Sewerage—Main Sewers and House Branches, Traps, Ventilation, &c.

Even where conservancy systems are used for the removal of refuse excretal matters, it is necessary to have some contrivance by means of which the foul waters can be got rid of. In country places, it may be discharged into ordinary agricultural drains laid beneath the garden. It then percolates into the soil, and serves to fertilise the crops. If, however, such waste water is thrown gradually down the traps and into the drains a small quantity at a time, the water escapes through the junctions of the first few pipes, and the fat and other solid matters become deposited in them, and soon choke up the pipes; so that it is necessary to collect the slop-water, and discharge it at intervals. The best contrivance for this purpose is Mr. Rogers Field's flush tank, of which I have here both an actual specimen and a large working model, kindly lent by Mr. Field. The slop-water is discharged over a loose iron grating at the top, and passes through a funnel-shaped aperture with a syphon bend at the bottom of it, which can also be lifted out, into the tank below. The discharge-pipe from this tank does not start from the top of it, but very near the bottom, is carried upwards to the top, and turns over and passes downwards to its outlet, which is at a lower level than the point from which the pipe began. This pipe is made in the earthenware end of the tank itself. Thus it will be seen that a syphon is produced, so that when the tank is filled to the top, and the shorter limb of the syphon also filled up to the bend, a sufficient quantity of water thrown in suddenly will start the syphon, and so empty the tank of its con-

tents to the level from which the lower limb starts inside the tank. The discharge end of the syphon has a weir placed across it with a notch in it. By means of these contrivances, not only will a smaller quantity of water start the syphon, but a false action, which was found occasionally to take place, and which caused the water to dribble away without the tank being emptied, is prevented. Thus the whole body of water contained in the tank is made to rush through the drains, and the difficulty spoken of above is avoided. The tank also acts as a very good fat trap. In towns, however, it is necessary to have sewers for the removal of the foul water. Sewers ought to be impervious to water, so that their contents may not percolate into the soil around, and so drains which are made to dry the soil are obviously not fitted to be used as sewers. The larger sewers are usually made of bricks, and built with an oval section, this being preferable to the circular, and of course far better than any rectangular section. The bricks should be of the very hardest kind, and set in cement, and it is advisable to build the "invert," or lower part of the sewer, upon invert blocks made of stoneware. For smaller sized sewers stoneware pipes are the best. They should always be used for sewers not greater than 18 inches in diameter. Larger sewers than these are cheaper made with bricks set in cement. Stoneware pipe sewers would be much more used than they are in towns, but for the fact that the estimated size of the sewers generally is usually larger than is required, and much larger than would be required if the rain and surface water were carried away by separate drains. The pipe of the sewer only requires to be large enough to carry away the water that can be discharged into it, and anything beyond that size is an absolute disadvantage, as it makes it more difficult to flush the sewers properly, for a larger pipe is insufficiently flushed by a quantity of water that would easily flush a smaller one. For flushing purposes it is best to have an arrangement by which a considerable quantity of water is delivered into the sewer at once, so that it may fill it, or nearly so. The same quantity of water delivered more gradually does not produce by any means the same effect. In laying sewers, whether main or house sewers, provision should always be made for making new connections without cutting into the pipes. This may be done by putting in junctions at various points—a plan especially suited for private estates, where the points at which junction may be wanted will suggest themselves. With street mains more ample provision should be made. Mr. Jennings's pipes, which allow of the sewers being opened at any point without cutting the pipes, may be used. The pipes, in fact, have no sockets, the place of the sockets being supplied by divided rings, in one half of which the pipes are laid at their junctions, while the other half covers the upper part of the junction. With ordinary socket pipes, Messrs. Doulton's slidded pipes may be used with advantage. In these a third of the pipe can be taken off along the whole length of the pipe, and so junctions can be made, the pipes inspected, and cleaning rods pushed down them when necessary. The "capped" pipes made by Messrs. Jones and Company, of Bournemouth, are also useful. They are constructed in the following way:—A semi-circular or semi-elliptical hole is cut out of each pipe at its end, so that when the pipes are socketed a circular or ellipitical hole is left at the junction between the two. These holes are closed by means of lids made for the purpose, which may be removed at any time, for the purposes of inspection, inserting a junction, &c. The above remarks apply to house branches as well as to main sewers, and it is very important not to omit the insertion of inspection pipes, of some kind or another, at proper intervals and suitable places, in house sewers, especially those of large mansions.

The main sewers should be freely ventilated at the level of the streets. All attempts to ventilate them in any other manner have been, without any exception, signal failures. If the ventilators, whether of main or of branch sewers, cause a nuisance, it is because there are not enough of them, or because the sewer is either badly laid or not properly flushed. In country places especially, cesspools are often the destination of the house sewers. Cesspools should never be made where it can be helped. It is far better to use the sewage on the land than to collect it in cesspools. However, in some places, cesspools are necessary, in which case they should always be made impervious to water, by being built of bricks set in cement and rendered in cement. The cesspool should not be under the house, but at some distance, and it must be ventilated. If near to the house, the ventilator should be carried up outside the wall of the house, and above the ridge of the roof. If at some distance, it may be ventilated either by means of an open galvanised iron grating, or by means of iron pipes carried up a tree and covered with wire network at the top. The cesspool should not overflow into a stream, or drain running into a stream, but on to the surface of the ground; and it is folly to build a second cesspool, as some people do, for the first one to overflow into, for, by the same argument, one might build any number—one after the other. Brick sewers should never be used under houses. The foul water soaks through them into the soil, and sediment is liable to accumulate in them. Rats eat their way through them, displacing the bricks and wandering about the house, and so not only does foul water get out of them into the soil, but foul air finds its way wherever the rats go, besides the fact that rats carry filth from the sewer itself about the house, and into the larder if they can get there. In this way, I have no doubt whatever, that milk and other foods have disease poisons frequently conveyed to them. Sewers made of glazed stoneware pipes should always be used for houses, except in cases where it may be better to use iron pipes, and they should always be laid outside the walls of the houses whenever it is practicable. They may require to be laid in a bed of concrete, as for example, where there is much made ground, or to be laid on hollow invert blocks in very wet soils. They should be jointed with cement, or, where a settlement is feared, with clay, finishing with a ring of cement. Clay alone is not advisable, as it is apt to get washed out of the joint, in which case the water runs out into the soil, and the solid matters accumulate in the sewer. If pipes, with Stanford's patent joint, made by Messrs. Doulton and Co. (of which I have some examples here), are used, no cement is required. The ends merely have to be greased and fitted into one another. These

pipes must be laid straight, or they will not fit together, and at bends it is often requisite to use ordinary socketed pipes. The fall of a house sewer should at least be 1 in 48, but a more considerable fall is preferable; 9-inch pipes may be used for very large mansions, especially if outbuildings are connected with the sewer, but, as a rule, for private houses 6-inch pipes with 4-inch branches are amply large. The junction of the branches should never be made at right angles, but always at an acute angle, and of course in the direction in which the water is going. At the end of the house sewer, in the main sewer, or cesspool, a swinging flap made with galvanised iron is frequently placed, with the view of keeping rats out of the house sewers. It may be of some use for this purpose, but is of little use for preventing the entrance of foul air, and as may be expected, these flaps are often out of order. It is also usual to place a water-trap of some kind upon the house sewer before it enters the main or cesspool. The kind formerly most used was what is known as the dipstone trap. The drain was deepened at the spot, and a piece of stone or slate inserted right across the drain from side to side, and reaching from the top down into the deepened part, two or three inches below the level of the bottom of the sewer. Water of course always remained in the deepened part, and so the dipstone running right across the drain dipped about two or three inches into this water. As it reached also to the top, and was built in, it obviously prevented the passage of the sewer air from the main sewer or cesspool into the house sewer, except, at any rate, that which could pass through the water in the trap. These traps were usually made rectangular, and were often very large, so that they were practically cesspools, and they still go by this name in some parts of the country. They may be much improved by making the end nearest to the house vertical, giving the opposite one a gentle slope, and fixing the dipstone, not vertically, but slanting in the direction in which water goes—rounding off the inside with concrete rendered in cement, so that there are no angles or corners. Thus the water falls vertically into the trap and flows out through a gentle incline. In such a trap very little accumulation occurs. Stoneware syphon traps are, however, now almost entirely used. They are frequently made with an upright piece from the lower part of the syphon, which may be continued by means of straight pipes up to near the surface of the ground, for the purposes of inspection, and of cleaning out the syphon should it get blocked up. This inspection opening is now sometimes made at the end of the syphon which is intended to be placed next to the house, so that if pipes are carried from it up to the surface of the ground, and an iron grating put on to it, a passage is formed which, under ordinary circumstances, acts (if precautions are taken which will be presently mentioned) as an entrance for air into the house sewer. The syphons also are now made with the limb into which the house sewer opens nearly vertical, while the opposite limb has a gentle slope upwards—the effect produced being that already mentioned. It is a considerable improvement, although not absolutely necessary, to increase the air inlet into the sewer at this point, that is to say, immediately on the side of the syphon trap, and instead of merely having a pipe taken up to the surface of the ground, to have a man-hole built in brickwork, and with channel pipes instead of whole pipes running along the bottom of it into the syphon. The channel pipes and one or two pipes beyond should be laid at a considerable fall, so that the water may rush down into the syphon and clear it out as much as possible. Branch pipes may be made to join the main in the man-hole by means of channel pipes, or even by whole pipes discharging into a gutter built above the channel pipe; or they may of course be taken into the house sewer at any point of its course. The man-hole may be covered by a galvanised iron-locked grating, if it is in such a position that gravel, &c., is not likely to get into it, but if in an area it is better to cover it with a locking iron door, and to have one or two 6-inch ventilating pipes from its upper part carried under the pavement area to the wall, up in the wall a short distance, and then opening out by gratings flush with the surface of the wall. A junction pipe should be fixed immediately beyond the syphon and pipes brought from it through the wall of the man-hole, the end being filled with a plug, which can be removed for the purpose of cleaning the sewers beyond the syphon if necessary, or various earthenware disconnecting traps may be used. Potts's Edinburgh chambered sewer trap has the advantage of having a large air inlet, and a considerable fall in the trap itself. In many instances, with sewers already laid, sufficient fall cannot be got to introduce these traps. Weaver's trap is really a syphon, as already mentioned, with an upright air inlet leading into the limb of the syphon nearest to the house. Beyond the syphon an aperture is provided by means of which the main sewer, or cesspool beyond, can be ventilated, or which, if merely plugged, may serve as an inspection pipe, through which rods can be pushed, if necessary, down into the main sewers or cesspool. In Buchan's and Latham's traps the fall is quite vertical.

Stiff's interceptor may be described as a syphon-shaped trap, with a double dip, so that it has three compartments, with an open grating for the middle one. If any sewer air should pass under the first dip, it cannot get under the second, which is deeper, but will escape into the open air through the grating. Two inspection openings are provided, which may be also used as ventilating openings—the further one to ventilate the main sewer or cesspool, if necessary at this point, by means of a pipe running to the top of the house, and the one on the house side of the trap may be used as an air inlet. Professor Fleeming Jenkin has introduced the plan of using two syphon traps with an open grating between them. Dr. Woodhead has modified this by having a large earthenware receptacle, which all the house pipes enter underneath a large iron grating, with two syphons beyond the receptacle, one after another, and an upright pipe with an open grating between them. There is also a smaller upright pipe, with open grating at the top between the receptacle and the commencement of the first syphon. It is unfortunate that we cannot do without a water trap at all in disconnecting the house sewers from the mains, and I certainly do not think that any sufficient reason has been made out for having two traps one after another. At

the highest point of the house sewer, or, if necessary, at the end of one or more branches, there should be a ventilating pipe, four inches in diameter, carried up above the eaves of the house or above the ridge of the roof, and not under or near any bedroom windows. This may be covered with a little conical cap, or merely with a piece of wire network, or with a cowl (preferably a fixed cowl) if it is required to be ornamental. Whether this pipe be covered with a cowl or not, air will, as a rule, enter at the air inlet at the lower end of the sewer, pass along it through its whole length, and escape by the ventilating pipe or pipes just mentioned, and no foul air can accumulate in any part of the sewer. If any foul air escapes at the air inlets, it acts as a warning to show that something is wrong; the syphon is stopped up, or there is an accumulation of foul matter in it, or in the sewer somewhere. When all is going right, no foul air will escape by these openings. The ventilating pipes may be made of iron if only used as ventilating pipes. When used also as soil-pipes they are better made of lead, as will be further shown in the next lecture. Rain-water pipes may be taken directly into the house sewer or its branches without any trap, provided that their joints are well filled and packed, and that they do not open at the top near to any bedroom windows, otherwise they must discharge over the surface of the yard or area. The surface gulleys for yards, &c., may be stoneware syphon gulleys, provided with galvanised iron gratings, which are better than stoneware gratings, as they are less liable to break. They are sometimes provided with openings in the side above the level of the water for the admission of waste pipes, &c. Dipstone traps are sometimes used, but are objectionable. McLandsborough's gulley is sometimes useful. It may be described as an iron dip-trap with three compartments, having several openings, into which pipes may be taken above the surface of the water. Jennings's receiver is also often useful, especially where the trap has to be low down, and upright pieces placed one above another over it up to the level of the pavement. Pieces with openings are provided, so that drains coming from the inside of the house—the basement drains for instance—may be discharged into it, and so disconnected from the house sewer. Drains from the basement of a house ought not to open directly into the house sewer, but always into a disconnecting trap of some kind or another. Clark's gulleys are useful where much sludge is likely to be washed into the trap. They are provided with iron buckets that collect the sludge, and can be lifted out bodily. They are doubly and sometimes trebly trapped. The common bell trap, so often used, not only in areas, but in the basements of houses, is a most mischievous contrivance. It consists of an iron box with a pipe, which is connected with the sewer, standing up in it. The perforated cover of the box has an iron cup or bell-shaped piece fastened underneath it. Of course water stands in the box up to the level of the pipe which descends into the sewer. The bell on the perforated lid is so arranged that, when the lid or grating is in its place, the rim of the bell dips into the water around the vertical pipe. Even if the bell is in place, and whole, the trap is untrustworthy, because a very slight increase of pressure of air in the sewer will cause it to force its way through the small film of water into which the bell dips. It is objectionable because it soon becomes filled up with filth, and because, unless water is almost continually running through it, a sufficient amount evaporates to allow the sewer air to escape freely; but the great objection to it is that, when the cover is taken off, the bell is taken off too. The trap, such as it is, is gone, and the air from the sewer escapes freely into the house if the trap is inside the house. The covers are often taken off by servants, and left off, and are also frequently broken, and so the use of these traps should be discouraged as much as possible. The Mansergh trap is frequently useful in areas, as it serves also for the disconnection of the basement sinks, and provides a place of attachment for a ventilator for the house sewer. It consists of three compartments. Into an opening in the side of the first, the waste-pipe of a sink may be conducted. The water from this fills the first compartment up to the level of an aperture, through which it passes into the second, the pipe through which the water is conveyed into the first compartment being made to dip below the surface of the water in that compartment. Over the first and second compartments there is a loose iron lid with a grating over the second or middle compartment. From the second compartment, the water passes under a partition into the third, the outlet from which into the house sewer is above the lower edge of this partition, which itself extends from the top of the trap nearly to the bottom, so that it completely separates the air in the third compartment from that in the second, and dips beneath the level of the water in the two compartments. The top and sides of this third compartment are made of stoneware, so that it does not communicate with the external air, the outlet to the sewer being at one side, and an aperture to which a ventilating pipe may be attached in one of the other sides. Even if the last aperture be plugged up, and no ventilating pipe attached, any sewer air which can pass through the water from the third compartment into the middle one would escape by the grating into the open air, and could not get into the house, as the pipe from the house into the first compartment of the trap dips below the water. The cases in which it is more advisable to use this trap than ordinary syphon gulleys, will be mentioned in the next lecture.

NATIONAL WATER SUPPLY.

ON THE EFFECTS OF UNDER AND ARTERIAL DRAINAGE ON RIVER FLOODS.

By James Dillon,

Vice-President, Institute C.E., Ireland.

The pollution of rivers, the silting up of their beds, and the damage caused by river floods. renders legislation on the subject necessary, and this applies not alone to England, but to the United Kingdom.

True it is that great progress has been made with the removal of river floods in Ireland, but further legislation is required, and if certain alterations were made in the Act 26th and 27th Vic., and the Acts amending same, under which river works are carried out in Ireland, I have

reason to believe that an Act for England, drawn on nearly the same basis, would enable all the principal rivers to be successfully dealt with, whereas, if these amendments are not made, matters must soon come to a dead-lock in both countries; for this reason it is to be hoped that final legislation on this subject may extend to the whole of the United Kingdom.

Having charge of several river works in Ireland, I would wish first to state that, confining the floods in the upper reaches of a river valley within the river banks, instead of allowing the floods to spread over the banks, has not had the effect of increasing the floods to such an extent as to cause an increase in the damage done by the same floods in the lower reaches of the same valley below the termination of the upper works; and even admitting for the moment that, theoretically, drainage works may have increased river floods, still it has been found impracticable to measure or value the damage, if any, caused thereby.

Careful records have been kept of the River Shannon floods in Ireland, before and after the floods from some of its tributary districts were confined within their river banks, where formerly the floods were allowed to cover the land.

The engineer to the Board of Public Works, Ireland, Mr. William Forsyth (lately resigned), a man of great ability and sound judgment, and who had more to do with the river works in Ireland up to 1863 than any other man, in a report on the subject, dated 13th April, states:—That although eighteen tributary or sub-districts, having their outfall in the River Shannon, have been relieved of their floods, the daily registries of the depths of waters on the Lock Sills along the lower reaches of the Shannon, below the 18 districts, show that the discharge in a given time has not been materially increased by relieving the lands in the 18 districts from their flood waters. In the same report, Mr. Forsyth states, that the late Mr. James M. Rendel, C.E., of London, said it was established that all flooded lands within a rain basin, and sending their surplus waters to be carried off by the same main outfall river, have contributed to the cost of improving the common outfall, while they respectively managed the drainage of their own subdistricts independently.

The Earl of Rosse, in 1871, stated before a public meeting, held to promote the River Barrow improvement, that the drainage of a large flooded district above his demesne at Parsonstown, had not had the effect of increasing the volume of floods passing through his demesne to any appreciable extent, although engineers predicted that bridges would be carried away, and the demesne of Parsonstown flooded more than it had been.

Mr. R. Rawlinson, when giving his evidence in 1877, before the Lords Committee on Conservancy Boards, was asked, had the extension of drainage works very much increased the suddenness and violence of floods, answered, "I do not believe that either drainage or cultivation effect floods in any appreciable degree." (See page 21 of the Minutes of Evidence.)

Other eminent men expressed a contrary opinion, but I am not aware that they caused any measurments to be made of the volume of floods before and after the execution of works for confining said floods within the river banks. Having successfully treated several districts in Ireland for protection from floods and for drainage, I was asked by the late Duke of Leinster and others, in 1871, to report upon the effect of under drainage on river floods, and having made certain observations, and carefully considered the matter, the substance of my report was that the former had no appreciable effect on the latter. This led to my being asked to report by different landed proprietors, upon the proposed River Barrow drainage, embracing some 625 square miles of a river basin, and finding the various interests so conflicting, I was forced to abandon the idea of carrying the work out as a whole, the cost of which would exceed some £300,000.

I pointed out the great advantages to be derived from carrying out the works in sub-districts under the superintendence of Local Boards acquainted with the localities with which their interests were connected. Accordingly, I was directed to proceed with the carrying out of two of the sub-districts. I at once met with great opposition, on the ground that I would flood the lower valleys, but I proved to my opponents I would not, and I am now completing both sub-districts successfully without increasing the destructive effects of the floods lower down the valley.

I believe few engineers have had the opportunity of recording the volume of river floods, before and after the execution of works for confining them within their river banks.

The following is the substance of the results I have arrived at in the case of the Upper Inney River Works. These works extend over 82 miles of rivers and tributaries; the catchment basin or area of country discharging its waters into this system of rivers extends over 278 square miles, and its centre is situated about 53 miles to the west of Dublin, at a level of 211 feet above the sea, the rock formation being limestone.

The whole of the river works were designed so as to carry off about four feet below the surface of land, the flood waters which formerly saturated and covered with water 12,260 statute acres of land, equal to seven per cent. of the catchment basin. During the progress of the works, it was necessary to carry out extensive rock, gravel, and other excavations, and to rebuild 60 bridges, the total cost of which amounts to about £60,000.

The works under my charge were commenced near Lough Iron, at the point where the Lower Inney Works, carried out under the direction of the Drainage Commissioners of Ireland, were suspended on account of their excessive cost and want of funds to proceed further up country.

Previous to the commencement of the Upper Inney drainage works, the average summer discharge in the river from the upper district amounted to ·0689 cubic feet per acre per minute, and the average flood discharge to ·4896 cubic feet per acre per minute. After the execution of the works, the average summer discharge at the same place amounted to ·0827 cubic feet per acre per minute, the flood discharge to ·4827 cubic feet per acre per minute. Almost similar results have been obtained by me in other districts.

In the paper I read before the British Association last year, I endeavoured to point out why such

results should be expected, and as I hope to continue my observations in connection with several other works I have now in hand, I may hereafter be able to throw some new light on this interesting and important question.

There is no doubt that since the publication of the facts and papers above referred to, many men of great intelligence have admitted to me that, after careful observation of the floods below the different new river works, they were beginning to think that the views I entertain on the subject are very nearly right, namely, that although under drainage may slightly increase the volume of floods in winter from the uplands, still, by providing a suitable channel of sufficient capacity through a somewhat flat river valley, that it has the effect of equalising the flood discharges through the same, by drawing off, at the commencement of the floods, from the inner portion of the river basin (before the floods from the more distant portion of the same basin reaches them), some of that flood water which, before the execution of the works, would have covered the river valley, and which, if left there, would have prolonged the duration of the floods, when passing from the surface of the valley to the lower reaches of same valley, while at the same time under drainage does certainly increase the summer flow by gradually drawing off the water, which would otherwise escape by evaporation in summer, when most required for use.

Mr. Denton, when giving his evidence before the Lords' Committee, in 1877, above referred to, is represented to have estimated the extent of land systematically under-drained in England and Wales at 3,300,000 acres, or, approximately, about one-twelfth of the surface of England and Wales; as some of this drainage is likely to be very imperfect this may fairly be considered an over-estimate. It is known that most river basins are composed of a very undulating surface, embracing hills and sometimes mountains, so that the flood waters are in constant motion over the same. If, therefore, the flood volumes from eleven-twelfths of the basins in England continue to reach their river valleys in the same volumes and at the same rate in 1879 as they did 300 years ago, the eleven-twelfths not being under-drained, how can it be possible, admitting for the moment that there may be a small increase, theoretically speaking, in the floods from the one-twelfth of drained land, that such a slight increase from one-twelfth of the surface of England and Wales could increase, to any appreciable degree, the eleven-twelfths of the unaltered flood volume from land not under-drained.

Again, I believe it will be generally admitted that there is but a small fractional quantity of the surface of each river basin actually covered with water in flood time. The average proportion of land covered by the floods in river valleys in Ireland does not exceed four and one-fifth per cent. of the entire river basin, and as the surface line of these floods have all more or less a considerable declivity, the whole of the floods from the 95 per cent. of the river basins must continue to flow into the river valleys at the same rate before and after the execution of any works in these valleys, so also must they continue to flow out of these valleys, on account of their declivity, for it is, I believe, admitted by the majority of engineers, that there is but a small fractional portion of river floods actually covering the surface of the lands, compared with the large volumes rushing down the rivers. It is, I think, unfortunate that so many men of eminence still hold to the opinion that the destructive effects of modern floods are, to any appreciable extent, due to the extension of under-drainage.

What I fear is, that hasty legislation, based upon this latter theory, will become so unpopular, should it give the power to any constituted body to tax the dry up-lands on the side of a mountain in one county, for the benefit of reclaiming flooded lands in another county, that such legislating must ultimately retard rather than promote the formation of Conservancy Boards throughout the country, having for their object the proper regulation of the rivers, particularly as eleven-twelfths of the land in England has not been under-drained, and, therefore, has not contributed to the increase of floods.

It would be easy to point out the different causes all contributing to raise the flood levels in certain districts throughout the country, although the flood volumes may not have been increased to any appreciable degree.

We know, however, that most river valleys are being gradually filled up now, as well as in former times, and that, under these circumstances, the multiplication of new fixed and permanent obstructions throughout these valleys renders the formation of some central governing authority necessary to check a further development of such evils.

Having endeavoured to prove that the increasing destructive effects of river floods are not due to the under-drainage of one-twelfth of England, but more to the increase of towns and artificial obstructions in the river valleys. I will pass on to the second part of this paper.

On the Incidence of Rating, &c.

It was generally admitted, until very recently, that no mountain, hill, or other dry up-lands in a river basin in one county could be taxed for the drainage of lands in another county; there may no doubt have been exceptional cases more calculated to prove the rule than otherwise, but I understand that in England, in the great majority of cases, the tax for river improvements has been limited to the lands proposed to be benefited by drainage, or relieved from floods, as the case may be. I am, however, in a position to speak with more accuracy as to the universal law on this subject in Ireland, as I have much to do with defining the boundaries and regulating the tax of several of the districts in which river works are now being carried out under my direction. The law in Ireland, down to the present time, is that no lands can be taxed for river works unless damaged by saturation or river floods; therefore, it is only the damaged lands that practically constitute the district, and pay for the improvement works. Previous to 1842, no river work could be formed unless the owners of two-thirds of this damaged land assented to a drainage district being formed, under the central Board sitting in Dublin. (See Drainage Acts passed for Ireland in 1842-45-46 and 48.) The 9th Vic., cap. 4, reduced the assents required from two-thirds to one-half, as it was found impracticable to obtain assents amounting two two-thirds.

Under this amended Act, 266,736 statute acres

were relieved from the effect of floods at a cost of £2,390,612, but the works proved so costly, and the Act became so unpopular, that, in 1853, the Treasury in London intimated that they would make no further advances, and accordingly no new works were sanctioned, another proof that central Boards are not suitable for the carrying out of very large districts.

Then, in 1863, owing to previous agitation in and out of Parliament, the Government sanctioned a general drainage Act being passed for Ireland, authorising private parties to form drainage districts (see Act 26 and 27 Vict., c. 88, and Acts passed amending same), provided that two-thirds in value of the injured land are owned by parties assenting to the project, and if the two-thirds petition, the Government will grant the necessary money to carry out the works, if satisfied with the financial prospects of the undertaking.

The progress of arterial drainage works in Ireland, under 26 and 27 Vict., c. 88, from July 31, 1863, was as follows:—Under this Act the works for 37 districts have been sanctioned, and are now nearly completed. Their effect has been to drain and free from floods not less than 71,000 statute acres, at a cost of £389,000, equal to an average outlay of not less than £5 9s. per acre, as compared with £7 per acre under the 5th and 6th Vict." Notwithstanding that the above results, as regards Ireland, are so far satisfactory, still it is a fact that year by year such works are becoming most difficult of accomplishment, owing to the impossibility of adjusting the conflicting interests of the upland and lowland proprietors. If the lowland proprietors promote a scheme for the improvement of the larger, and consequently more costly, sections of the rivers, they generally try to tax the upland proprietors (owning flooded lands) for works that can confer no benefit upon them, while if the upland proprietors try to improve their smaller and less costly rivers, they are opposed by the lowland proprietors, who erroneously contend that their floods are made worse by the drainage of the uplands, &c.

The extent to which these supposed conflicting interests interfere with the carrying out of such works may be judged from the fact that the Board of Public Works, in Ireland, in their report for 1877-78, announce that from Ireland last year there was only one application for a new drainage district; so that, unless subsequent legislation proves more successful, there will be few, if any, useful works of this class carried out when those already sanctioned are completed.

One great defect in the Act of 1863 was, requiring assents to a work amounting to two-thirds, when it was known that this proposal had to be altered from two-thirds to one-half in 1848; but although last year a special Act was passed again, altering the two-thirds to one-half, it is believed it will not be sufficient to overcome the present state of conflicting interests, owing to the variety of tenures, and the conflicting interests between landlord and tenant.

Another defect is, that the Commissioners of Public Works have the power of determining whether the cost of the works should be repaid in 22 or 35 years, while the public consider that 22 years is much too short a time to allow for the repayment of the cost of permanent improvements.

Lastly, the Commissioners have the power of refusing to sanction the formation of sub-districts, even supposing one-half of the owners of the damaged lands are in favour, if one-third are opposed to the improvements. (See Drainage Act for 1878.)

I have reason to think that a new Act for the United Kingdom, drawn very nearly upon the same lines as the existing Acts for Ireland, omitting their defects above referred to, would confer a great benefit upon the people in the three countries. Under a new general Act, I would provide that the owners of one-tenth part of the flooded lands, having formed themselves into a committee, should be given authority to apply to the Board of Works or the Local Government Boards (whichever might be considered best by Parliament) for permission to make a preliminary survey and section of the main river in any river basin from the outfall of that basin, to whatever distance up the country the floods injuriously effected the lands adjoining.

This survey should record the dimensions and levels of the main river, as well as all artificial works in same, and the approximate ordinary flood discharges of the previous winter from each of its tributaries, as well as the approximate discharge of the main river floods a little below the junction of each tributary, and on the section should be marked the levels of the highest-known flood; on the plan should be marked the population and position of all towns and villages, and their sewage works or their outfall for same, together with two blue contour lines. Contour line No. 1 should embrace all lands covered with flood waters. Then, supposing the surface of the floods were frozen throughout the entire river valley, contour line No. 2 should embrace all the land lying 5 feet above the ice surface throughout the valley, so to speak. On the preliminary section should be marked, by the committee's engineer, the height of the proposed embankments, or the dimensions and character of the proposed excavations and other new works. The committee should then forward a petition to the Board of Works, or Local Government Board, defining the different subjects to be treated, and asking them for a report on the project.

No further expense should be incurred until the central authority above referred to received a report from their engineering department, defining the sub-districts into which it would be practicable to subdivide the river basin, according to the position of the natural falls in existing flood levels (I mean by natural falls, that the floods in a river valley may have nearly uniform gradients for long distances, but that at the end of some 20, 30, or 50 miles, a fall of several feet may be concentrated within a space of half a-mile, and the division of a sub-district might terminate on the down stream side of that half-mile or natural fall), revising, if necessary, the proposed scale of works, while pointing out the order in which the works in the sub-districts could be carried out. Should the report state that, from an engineering point of view, the work was practicable, then the Local Government Board could make an order defining the sub-districts. This order should also define the proportion in which each of the sub-districts should contribute towards the cost of the preliminary survey, and cost of provisional order up to that time, based upon the land within contour line No. 1 on petitioner's map, at a fixed rate per

acre, the money to be paid to the committee through the Local Government Board or Board of Works, should the project have been reported upon as practicable from an engineering point of view. One year should be allowed to the petitioners to ascertain whether the owners of one-quarter of the damaged land in each sub-district, as marked on the preliminary plans, would aasent to the formation of a local Board to carry out their sub-division of the work, the cost to be borne by the damaged lands in proportion to the benefit derived, less whatever proportion of the total cost of the work might, by arbitration, be assessed on the towns and villages, owners of mills and fisheries, that would be benefited by the new works.

No portion of the money, however, should be raised, nor any part of the work commenced, until the schedule defining the proportion in which the different interests should contribute was finally determined, the schedule in the first instance to be prepared by the local Board, all matters of dispute as to values to be determined by arbitration.

The general Act should provide that upon all matters of dispute as to scale of assessment being finally settled, authority should be given for the Treasury to grant a loan for the works, principal and interest to be repaid in 35 years, and in exceptional cases, where works were very heavy and costly, say in 45 years.

Should the loan for the works be granted, then all preliminary expenses incurred between the completion of the committees' preliminary survey (previously paid for) and the granting of the loan, should be paid out of the first instalment of the loan.

If from any cause, however, the loan was not asked for or granted, then the sub-district Board should have to assess themselves for the expenses incurred; this latter condition would be the "main spring" of the whole scheme, as all would have a strong inducement to surmount any little local difficulties that might exist, rather than to pay for the expenses incurred by the new sub-district Board, without obtaining any benefit beyond having the plans for a future occasion.

The preliminary schedule accompanying the preliminary maps might, in the first instance, contain one quantity for the land, and one sum for the approximate increase in the actual value of the land when protected from floods or drained, as the case may be, within each sub-district; or possibly for each of the townlands or other denominations marked on the preliminary plans, so as to avoid the expense of preparing the detailed surveys and valuations, which should contain the contents of each parcel of ground, its present actual value, and probably increased value and decimal proportion in which the different interests should contribute, until after it is known whether the sub-local Boards would be in a position to adopt the report of the Local Government or other authority defined by Parliament.

Thus, at a very small expense, the preliminary and general design for river conservancy or drainage works could, at the outset, be submitted to one central authority, so as to ensure that the proportion and scale of the proposed new works should be uniform throughout the whole river basin, in proportion to the flood volume to be discharged by the different sub-districts, while, at the same time, enabling each sub-division of the work to be carried out by each sub-Board in proper order, and with the same uniformity as if the whole main outfall works had been let under one contract.

This method would also have the advantage of enabling each sub-district to ascertain, more closely than by any other method, what the approximate cost of their divisions of the work would be before commencing them.

The above is a mere outline of a proposal which, if I had time and space to develop, would, I believe, be found to get rid of some of the principal defects in the law, as it now exists, relating to river conservancy works; I know it would get rid of the great difficulties now met with in Ireland. Unless the people in flooded districts, throughout the kingdom, can be furnished with inexpensive surveys, showing how their different interests could, at a comparatively small outlay, be beneficially affected, it will, I think, be found impracticable to induce them to work harmoniously and for their own benefit. At least, this has been my experience from 1856, during which time I have been instrumental in bringing about the formation of several sub-districts, but not until I had to overcome much opposition and difficulties. It would, I think, be premature to form any definite opinion of the River Conservancy Bill that has been read a third time in the House this session, until it is seen how the Commons are likely to deal with it. I cannot help thinking, however, that should this Bill in its present form become law, it is likely to become an unpopular measure in England, on account of the power it would give to tax a dry, hilly, or mountainous district in one county for river conservancy works, or the draining of wet land in another county (purchased perhaps, a few years ago for a small sum of money); and although it is not proposed to extend the Act to Ireland, still it would prevent the owners of flooded land in that country assenting to any new works, in the hope that a similar Act would be passed for Ireland. While the law having for generations secured the owners of dry up-land in Ireland from contributing towards the drainage of wet lands, they would be forced to get up an agitation that would for years prevent any extension of river conservancy works in that country, and I am inclined to think the same objections may apply to England. If it can be shown that a River Conservancy Act, based somewhat on the above proposal, would undoubtedly confer a benefit on one part of the United Kingdom, it can do no harm to carefully consider whether the same Act might not be made applicable to the whole country.

In the event of Parliament requiring that all interests proposed to be taxed for river conservancy works should be represented, in proportion to their interest, on the Boards having the powers to tax them, I much fear that as over 90 per cent. of the land in each river basin would be above the influence of river floods, that the owners of that land would be powerful enough to successfully resist or defeat any proposal to tax their lands for river works, required to relieve from the injurious effects of floods or pollution the remaining 10 per cent. (in many cases not so much) of the river basin, and possibly belonging to another set of proprietors, while the scheme I propose would avoid this latter danger.

RIVER CONSERVANCY, ILLUSTRATED BY DRAINAGE ADMINISTRATION IN HOLLAND.

By J. Clarke Hawkshaw, Memb. Inst. C.E.

The word "Conservancy," when applied to rivers in this country, has generally hitherto been held to mean the keeping of them in a fit state for navigation. When our rivers were more used as highways, most of them had Conservancy Boards for navigation purposes. As long as such bodies prospered, our rivers were kept in far better order than they now are, not only for navigation but for other purposes. Some of these Boards have disappeared, some remain, and still retain their powers, but many are unable, for want of funds, properly to do their duties.

For this reason, and from the growth and spread of population along the river banks, new forms of conservancy have become necessary. Pollution by town refuse led to the passing of the Rivers Pollution Prevention Act, in 1876. The greater frequency of floods during late years has made it plain that conservancy for their prevention is necessary, and has given rise to the Rivers Conservancy Bill of this Session in Parliament.

Land Drainage Boards we have in plenty; each one does something, often little enough, to ward off floods in its own district. But their sphere is too limited, they rarely look beyond their own narrow banks, and they will not work together. What we want to find out is how to control and direct their work, so that, when possible, it may be made to benefit all, and also to aid it by works which no one of them could undertake.

Some advance has already been made towards the same end in other countries, and we may help ourselves in our difficulty by seeing how it has been met elsewhere.

Of all neighbouring countries, Holland has the most artificial system of drainage. The very existence of the country depends on the water in and about it being kept under proper control by artificial means, and this has been the case from very early times. We might therefore reasonably suppose that the necessity for laws to control and provide for the management of rivers and water channels would soon have been felt, in Holland and such we find to have been the case.

Unions for drainage purposes of all lands, high and low, have existed in Holland for several centuries. Such unions are called "Waterschappen," and their oldest charters date from the 13th and 14th centuries.

In early times, the Boards of the Waterschappen were composed of the already existing corporations, and the Government of the day named persons, called "Heemraden," to control and superintend the land drainage works which the corporations carried out.

Under these corporations no great progress was made until the 15th century. As the importance of the works which were undertaken increased at that time, so also the necessity then arose for a more complete organisation, to supervise and control them, and more important administrative unions, called "Hooghecmraadschappen," were accordingly instituted on a basis which has remained practically unchanged to the present day. A Hooghecmraadschap is a Waterschap, whose Board is composed of a "Dykgraaf," or president, and "Heemraden," or directors, with power to execute and maintain all the drainage works in which the inhabitants of their district have a common interest, with power to control all the minor works carried out by the small drainage corporations, or "Polders," andto enforce obedience on the part of private landowners and Polders to such laws as they may from time to time make.

The following powers are possessed by all the Waterschappen:—

1. In cases of emergency, when floods are imminent, they may execute works, or remove existing works, at the expense of those who should execute or remove them, but who fail to do so.

2. They may appropriate any materials which may be of use in repelling floods. The compensation to the owners to be settled afterwards.

3. They may take the earth required to make new or restore old embankments. The compensation to the owners to be settled afterwards.

4. They may levy rates to defray their expenses.

They may, moreover, by a law of 12th July, 1855, inflict a fine, not to exceed 25 florins, or imprisonment for from one to three days, for infringment of their regulations. The intervention of a judge is required, however, to legalise these punishments. They may also shut up or put out of use all the watermills, sluices, or other works by which interference with their regulations has been brought about, and this may be done at the expense of the offending owners. The Hoogheemraadschap of Rhineland is one of the most important of the large drainage districts in Holland, and I will describe its constitution in somewhat more detail, from information kindly furnished by its president, Mr. J. S. Clercq, and by Mr. J. Waldorp, the eminent Dutch engineer.

Its first charters were granted by William II., Count of Holland, in 1255, and by Count Floris V., in 1285. It extends from Amsterdam to Gouda, over an area of 262,685 acres (106,282 hectares). It is bounded on the north by the margin of the recently reclaimed Lake Y, on the west by the North Sea, and on the south and east by the Hooghecmraadschaps of Delfland and Amstelland, There is an adjoining district of Woerden, 41,992 acres (16,990 hectares) in extent, which pays a fixed contribution for certain sluicing privileges, but which forms by itself a separate Waterschap.

The administration of Rhineland consists of a combined board, composed of 16 chief or principal landowners, six members, called Hoogheemraden, and a president, called Dykgraaf. The Dykgraaf and six Hoogheemraaden form an executive board, over which the Dykgraaf also presides, and which is assisted by a secretary, a receiver, and a civil engineer.

Besides the 16 chief landowners, there are 16 chief landowners assistant. The two together form an electoral body of 32 in number, which meets once a year, to select three persons, either for Hoogheemraden or Dykgraaf. This list is submitted to the king, who chooses one of those named in it to fill the office.

No one under 23 years of age can be a member of the Board, or a member of the electoral body, and in order to be elegible for the office of Dykgraaf or Hoogheemrad, a person must be the owner of at least 62 acres (25 hectares) of land in Rhine-

land, and chief landowners and chief landowners assistant must own at least 50 acres (20 hectares). Relations nearer than the second degree cannot serve together.

Rhineland is divided into 16 electoral districts, each of which elects one chief landowner and one chief landowner assistant. All persons, companies, and corporations paying yearly taxes for not less than $2\frac{1}{2}$ (1 hectare) have a right to vote. The payment of taxes on $2\frac{1}{2}$ to $12\frac{1}{2}$ acres (1 to 5 hectares) gives the right to one vote, and so on up to 200 acres (80 hectares) which gives the right to the maximum number of votes, which is ten. The vote may be given by written procuration.

All the members of the combined Board, including the Dykgraaf, and also the chief landowners assistant who serve only on the electoral Board, are elected for six years, and a certain number retire each year.

The combined Board has charge of everything connected with the constitution of the district; it decides on the regulations to be enforced, and on the measures to be taken to enforce them; it decides on the execution and manner of carrying out all new and extraordinary works; it determines the right to pump or sluice on to the general bosom or upper catchwater; it buys, sells, and leases the property of the Hoogheemraadshap; it decides when action shall be taken in the courts against those who fail to comply with its regulations; lastly, it settles all disputes between the landowners or minor polder Boards. Against its decisions in such cases appeal may be made to the Deputy States of the province; in the case of Rhineland, to the Deputy States of North and South Holland.

The executive Board, consisting of the Dykgraaf and Hoogheemraden has charge of the execution of the resolutions of the combined Board. In cases of emergency, it may act independently, and at such times it may carry out any works it thinks necessary, may make banks, occupy land, and take any materials it may require from adjoining occupiers.

The executive Board may order the removal of any obstructions which interfere with the drainage of the district, or it may remove the same at the cost of the owners if they fail to do so; it regulates all deep excavations, whether for peat or other purposes; it sees that proper precautions are taken to prevent the sand of the sandhills from blowing away; it fixes the level at which the water has to be maintained in the different catchwaters or bosoms; it controls, in fact, all works affecting the drainage of the district.

The Executive Board publishes the regulations, and sees that they are enforced, and it keeps a correct register of all the taxable lands of the district.

The Dykgraaf is charged with the execution of all the resolutions of the Executive Board, and he has control over all the officials of the Hoogheemraadschap. In cases of immediate danger, he may act independently, with the full power of the Board.

The regulations prepared by the executive Board, after being open for public inspection, for 14 days, are submitted to the combined Board, who send, them with or without modification, to the Deputy States for approval. After being approved by the Deputy States, they are published, and eight days afterwards are in force.

The yearly budget, which includes the salary of the Board and its officers, the expenses of the Board, the cost of maintainance of all ordinary and extraordinary works, and all other expenses, is prepared by the Executive Board, is settled by a general meeting, and has then to be approved by the Deputy States of the province. At the same time, the tax to be paid by the landowners is settled for the following year. The tax is fixed at an equal rate per hectare (with a few exceptions, resulting from old contracts, or for reasons which will be referred to later on) and is the same, whether the lands are high lands, or low lands. Uncultivated sandhills, and the water area of the bosom, and bosom canals are free from taxes. The average yearly tax paid during the last 50 years in Rhineland, has been one shilling and four-pence per acre (two florins per hectare); the maximum tax in any year was two shillings, and the minimum eight-pence per acre (three florins, and one florin per hectare).

The Budget, after being open for public inspection for 14 days, is printed and published, and the same course is pursued with regard to the amount of receipts and expenses for the past year.

All payments are made by the Receiver (Rentmeester) and the certificates are signed by the president and one member of the Executive Board. All other documents are signed by the president and secretary.

The taxes are paid in accordance with the register, which contains a correct description of all the properties in the district. This register is open for public inspection, during a fixed period.

If Rhineland neglects to execute necessary works, the Deputy States may order the execution of them, or may undertake them themselves, and charge the cost to Rhineland the Deputy States may also propose to the King the dismissal of the Dykgraaf or Hoogheemrads, when they are either inefficient, or when they fail to carry out the requirements of the Deputy States. In all cases the King decides between the two. Any information which the Executive Board may require from the Polders Corporations in Rhineland, must be supplied by them, and they must submit to the Board their yearly budget, and an account of their administration. They may, however, appeal to the Deputy States against the Board's decisions.

In the years 1854-5, the Provincial States of North and South Holland settled general rules for the administration of the Polders Corporations, 230 in number, over which the Rhineland Board has general control. Each Polder has its own special rules.

Any resolution of the Hoogheemraadschap, or of the small administrations of Rhineland, may be annulled by the deputy states, if it is contrary to law, or if it is against the interest of Rhineland, or that of the province. The only appeal in such an event is to the King.

Such is the administration of the important district of Rhineland. Other districts throughout the country are governed in a similar manner.

It is generally thought in Holland, that the existing laws are all that is required to secure the good administration of the Waterschappen, and smaller drainage districts, or Polders, which they include. In confirmation of this opinion, I am

told that disputes between the different interests in the large districts do not often happen, and the right of appeal to the Deputy States against the decisions of the different Boards is very seldom used. It is, however, thought that a law is required to regulate the relations of the large districts to one another, to the towns, and to the navigations. Yet, although tho want of such a law has long been widely felt, the landed interest in the chambers, who are most interested in obtaining it, and who are, moreover, in a position to do so, have not yet ventured to move for it. The administration of the Waterschappen and Polders is so good, and all interests within them are now so well protected, that there is great reluctance to take any steps which may tend to disturb or lessen the authority of the existing Boards.

In a flat country like Holland, well-defined natural drainage districts do not exist. When drainage districts are not divided by natural boundaries, the interests of those which adjoin must often be opposed, owing to their making use of common channels for the discharge of land water, or from other causes; and hence arises the necessity for a law to regulate their mutual relations. In this country, no such necessity need arise, if the boundaries of the combined drainage districts are made to coincide with the natural boundaries of the river basins, which are well defined, except in limited areas, such as are met with in the few districts of the Eastern Counties, where flat, alluvial tracts stretch across the lower courses of two or more rivers.

The whole of each natural drainage district should be under one Conservancy Board; above all, it is important that the outlet, by which the waters of the district are discharged into the sea, should be under the same control as the rest of the district. On many rivers, it will be found that the cost of the works inland will depend, to a great extent, on what can be done to improve the outlets to the sea, and, if these outlets are not, in some measure, under the control of the Conservancy Board for the river, their difficulties and expenditure may be very much increased.

If Conservancy Boards are formed for drainage purposes with only partial jurisdiction over a river, they will always be able to drain their land, though, perhaps, at greater cost, without the cooperation of those situated lower down on the course of the river. But those so placed lower down will not save their pockets by not forming part of the same conservancy district, for unless they make provision for the more rapid discharge and greater volume of flood water, which will result from the works carried out above, they must suffer, more or less. This has happened in many places already, when works have been carried out by landowners on river banks without the co-operation of, and without regard to the interests of those lower down; and the same thing may happen if the drainage area near the river mouth is not under the same control as the rest of the river basin. Many of our ports are liable to be inundated by high tides, landwater floods, and combinations of the two. If the flood waters are passed to the sea more rapidly by improvements, this liability may be increased. It is therefore most desirable that no part of each natural drainage area should be left out of the union for conservancy purposes, least of all the lower parts adjoining the sea. If all are included, the interests of all can be watched and considered, and the best results may be obtained at the least cost.

In Rhineland, all lands, high and low, are obliged to contribute, in proportion to their acreage, to the general rate raised for the purposes of the Waterschap. Generally, the amount of the rate is the same, per hectare, for all. Exceptions are occasionally made in favour of some lands—when it can be proved that no benefit whatever can be derived by them from the works for which the rate is raised. In such cases the tax is not wholly remitted; the lands are taxed at a lower rate. The principle that all lands, high and low, should contribute, is, I think, fair and right, but it may appear unjust that the rate should ever be of the same amount for the two descriptions of land. It must, however, be borne in mind that in Holland lowlands bear a very much larger proportion to the total land than in this country.

For example, the total area which drains into the general bosom of Rhineland is 302,600 acres (122,450 hectares). Of this, 26,740 acres (10,821 hectares) only, that is, less than one-eleventh of the whole, consists of high land. This lies wholly within the district of the sandhills along the coast.

Of the remaining area 35,689 acres (14,442 hectares) are bosom lands. These are also held to be highlands in Holland, but they would not be called so in this country, as their average level is ten inches, (·25 metres) below the mean level of the sea. The polders or lowlands in Rhine-land lying from $3\frac{1}{4}$ to 5 feet (1 to 4 metres) below mean sea level, are 231,170 acres (93,546 hectares) in extent, and, lastly, the area of the bosom canals and lakes is about 9,000 acres (3641 hectares).

The bosom lands serve a special purpose in Holland. The water is pumped from the polders or low-lands into the bosom canals which run through the bosom lands, and it passes by them through sluices to the rivers or the sea. The bosom lands are liable to be flooded at times, indeed they form an additional reservoir space, to supplement that afforded by the bosom canals and lakes. The bosom lands, together with the bosom canals and lakes, form the general bosom of a district. Flooding of any part of the Polders is of the rarest occurrence. The pumps on which they are dependent are never stopped until the water rises to such a height on the bosom lands as to endanger the banks which divide them from the Polders. If the banks were to give way, all the water stored on the bosom lands would inundate the Polders. Rather than risk such a serious flood, the pumps would be stopped, and the rainfall would be allowed to accumulate on the lowlands for a time.

In the Fen districts of this country much of the land, corresponding to the bosom land of Holland, has been separated from the general bosom, and the receptacle for flood water has been thereby diminished. Such misappropriations are still going on, and, though a few landowners gain for a time by them, they, as well as their low-lying neighbours, must suffer in the end. The so-called dales along the River Witham were bosom lands; they now form part of the Fens, though the old banks which separated the two in former times still remain in places. In

Holland, no such conversion of the bosom land into Polder land would have been permitted. That the area now left for bosom water is wholly insufficient in the Witham district, was shown by the disastrous floods which happened in 1877. In this country there is no Board, as in Holland, with power to say when it is no longer safe to pump water from the fens on to the bosom. Each fen continues to pump, quite regardless of the height of the bosom water, which may often be running back over the banks to its own pumps. The banks must give way sooner or later, but each fen hopes that its own bank may not be the first to fail. The failure of a bank may cause one or more fens to be submerged to a depth of five or six feet, whereas a few hours' cessation of the pumping throughout the district, might often prevent such a disaster. In Rhineland, by stopping the pumps which drain the Polders, a serious flood may always be prevented; but it would not always be so in this country, for we have to contend with an immense volume of highland water, which is not the case in Rhineland.

It is now an accepted fact that the water from much of the highlands is discharged more rapidly into the rivers than it used to be. An owner of high land may say, "I bought my land subject to no charge for a river conservancy rate;" but with equal truth the owner of lowland may reply, that when he bought his land it was not liable to be overflowed by the large volume of water which the owners of the high lands now pour into the river by their improved system of drainage. But apart from such arguments, which are only of partial application, the principle that all lands should pay to maintain the main channels which, directly or indirectly, drain them is surely a fair one. If the incidence of rates is only to be determined by the benefits received, very many could not be justified.

No doubt the lowlands will benefit most, as now they suffer most, and they should bear the largest burden of the cost, the more so as they have to some extent rendered themselves more liable to be flooded, and have in many cases made the works which will be required to prevent floods more difficult to design, and more costly to execute.

In the first instance, costly works will often be required; works designed only to meet local requirements will have to be done over again, or be done away with altogether; obstructions will have to be removed which have grown up in the river channels, from natural causes, during years of neglect, or which may have been placed there to benefit individuals.

But even for such works no such rate need be feared as the land in Holland is subject to. Holland has to provide an artificial drainage for nearly all the land; we have, in most cases, only to provide that a good natural drainage system is kept in order, for, fortunately, the land in this country, which is without a good natural drainage, is very small in extent, when compared with the whole area.

To make a satisfactory law which shall provide for the government by one body of such large districts as are drained by our rivers, is a task of extreme difficulty. To put it in practice will be more difficult. The interests which have to be dealt with are so many and so great that it will be impossible to satisfy all. In Holland, where want of such a general law is more keenly felt than here, they have not ventured yet to prepare it. Still, they are far before us in river conservancy. They have large districts admirably administered, and under the charge of able drainage engineers, and they, moreover, have recognised the principle that all land should contribute to maintain the channels which convey the water flowing from it into the sea.

THE SANITARY STATE OF THE VALLEY OF THE RIVER SHANNON REFERRED TO BAD REGULATING WEIRS.

By **James Lynam**, C.E., of Ballinasloe.

To regulate the flow of rivers so as to restrict them from doing evil, and to lead them to do good; to prevent injurious inundations, and provide for fertilising irrigation; to maintain useful lines of navigation; supply good water to towns; and to drain malarious marshes, and make them healthful, profitable lands, would be to confer immense benefits on these kingdoms. To accomplish all this is quite practicable. It has been done to a great extent in Ireland under the drainage laws, with money borrowed from the Government on easy terms. Every one of those many loans has been, or is being, most regularly paid back, with interest, by the landowners who expended it.

The regulating of the English rivers is about to be commenced on a very large scale, under the law now being promoted by the Lord President. To bring rivers under the control of man, different regulating weirs are essential. I have reason to know that they may be designed and constructed of simple machinery, so as to very materially lessen thea mount of excavation which even the most eminent engineers have hitherto calculated on as necessary. Many patterns of regulating weirs in rivers are to be seen; some very effective, many very bad. Three patterns have been for many years in action in the River Seine. They are very effective, and fulfil the important object of regulating that great river, with an immensely valuable navigation from Elbœuf to Paris, and many miles upwards. Another pattern, more suitable to the English and Irish rivers, and more agreeable to our notions of permanent security, has been designed. The regulating weirs in the Shannon river in Ireland are on the same principles and style as those in the Severn. Solid masses of stone work, extending obliquely down stream, partly like a half parabola, without any sluice or flood-gate, or falling-board. In the Severn they are a success, in the Shannon they are an utter failure. The reason is, that the two rivers differ widely in circumstances and *régime*. The Severn has had but one summer flood in 40 years; it has frequent winter floods from the Welsh mountains, which rise rapidly, and cover the weirs several feet deep. The surface of the river just below the weir rises so high as to be very nearly level with the surface just above. Then "the whole trade goes over the top of the weir, where the river surface is practically level." The late Mr. Williams, the Severn engineer, stated he has seen "a whole train of vessels, half a mile long, behind a steam-tug, all taken over the weir, without knowing where it was."

The Marquess of Ripon asked—Have weirs on

this principle been built anywhere else than in the Severn? Mr. Williams answered—No. The adoption of this principle was the result of six weeks' discussion we had in Parliament in 1842. The Marquess of Ripon—As it has been in operation there for 35 years, is it not curious that it has not been adopted elsewhere?

The Shannon Commissioners, composed of five eminent engineers, adopted that principle, and built six such weirs across the Shannon. They are great, broad solid masses of stone, in plan resembling a half horseshoe, extending down stream obliquely for 1,100 feet length, where the river just above is but 400 feet wide, as at Killaloe and Meelick. But though these weirs have improved both drainage and navigation in the Severn materially, as described by Mr. Williams, in his evidence reported by the Select Committee of the House of Lords in 1878 (see evidence, pages 162, &c.), they have not at all improved the drainage of the Shannon, whose circumstances differ widely from those of the Severn.

The Shannon, for 111 miles above Killaloe, flows through a broad flat valley, with a fall of but $36\frac{3}{4}$ feet, apparently 4 inches per mile. But of that length $50\frac{3}{4}$ miles consist of broad deep lakes, having an area of 75,000 acres, capable of storing 6,000 million cubic feet of surplus flood-water. Broad, deep channels of the river between the lakes, of the aggregate length of 55 miles, are so capacious as to carry the flood-waters with a fall of merely 1 inch per mile. For 4 miles the channel is confined, causing a little obstruction to the floods. But the parts of the channel that are material obstructions, visible to the eye, are but two, about a mile long in all. From these circumstances it would appear that the Shannon may be very easily regulated, and its valley drained; and so it may, if proper regulating weirs were adopted. The present solid, wholly immovable weirs are the great obstructions in the Shannon. In dry summer weather they serve the navigation, and do no harm to the low lands, which are from two feet to five feet over the legal level of the navigation. In wet weather, which often happens in spring, summer, and autumn, they do very great harm to the land. As the surplus water increases from the rainfall, and finds no corresponding increased outlet at the weirs, it rises with every successive rainfall more than it can fall in the intervals, until it fills the river and lakes to the level of the low lands, or an inch or two under or over these lands. These conditions exist many years, during long periods in spring, summer, and autumn, not continuously, but at frequent intervals. In such intervals of small floods, there is not time for the low lands to become dry. It often occurs that the river is low in March and April, and many small farmers plant their potatoes, and sow their oat crops, and afterwards the river rises early in May, fills the drains and trenches, saturates the soil, and rots the seed. Such almost continuous saturation of the soil of the Shannon Valley, 150 miles long, and laterally along 17 tributary rivers, whose outlets are obstructed by the Shannon, is a very great public evil, so very injurious to the industry, the wealth, and to the health and vigour of the inhabitants. The atmosphere is much damper, and the temperature much colder than it should be. The land is, of course, far less valuable. Kind, nutritive species of the grasses cannot grow; coarse sedges, and soft aquatic plants occupy the soil. All attempts at farm drainage and improvement are impossible. In autumn frequent floods occur, of so small a magnitude, as could easily pass off by ordinary sluices; but there are none, and those floods go over the fields to a depth of merely a few inches for a few days. But they foul the herbage, and make it very unwholesome for cattle, quite unfit for sheep. The losses among the cattle and sheep by these causes are every year material, but this year may be reckoned by thousands of pounds. I have seen the crops on both sides of the Shannon for many miles rotting under merely a few inches of flood water, while at the weirs below, there was a clear fall of some feet, a cataract over each weir-wall. On one occasion I noted the falls over the weirs, when the valley was flooded by only from one foot to two feet of water. At that time the whole fall of the river, from the town of Carrick-on-Shannon to Killaloe was $36\frac{3}{4}$ feet. Of that fall, 21 feet were wasted in cataracts over six weirs, while $15\frac{3}{4}$ feet merely were spread along the surface propelling the stream.

The great winter floods make a continuous sheet of water 150 miles long, running laterally into many bays and tributary rivers, covering many public roads, surrounding and isolating many lots of high lands, and entering many dwelling houses. In one locality, I inspected 13 dwelling-houses so flooded. The people had constructed platforms of sods and stone under and around the fire-places. They showed me the stones and chairs on which they stepped to their beds, where they slept with several inches depth of Shannon flood water on the floor under their beds. The flood had then subsided $4\frac{1}{2}$ inches from its highest, as I noted by the marks it had left on the legs of the beds and tables. Many other families had abandoned their homes, and gone to the neighbouring towns till the floods subsided, when they returned to live and sleep in such apartments, with much danger to their health.

During all such times of misery, the weir mounds stand up firmly across the whole river, permanent artificial obstructions to the flood waters, robbing the river of half of its natural fall.

I cannot give the statistics of disease and death, in the saturated valley of the Shannon. I leave it to the humane minds of our philanthropists to imagine it, and to estimate how far this deplorable condition of a large and interesting district of her Most Gracious Majesty's kingdoms, is or is not due to her Majesty's Government. These most unscientific and unsuitable weirs were designed, recommended, and built by Government Commissioners. They have been maintained and defended, with all their evil effects, during 35 years, by Government Commissioners, who have bluntly refused several applications from proprietors for liberty to construct sluices in them.

To the great fault in the design of those wholly immovable weirs, those Commissioners added another great evil, when constructing one of them, viz., that at Killaloe. They built it a foot higher than is warranted by the Parliamentary section drawn by themselves, and recommended to Parliament, on diagram No. 39 in their second report.

They neither asked for, nor got any authority for that direct violation of the Shannon Improvement Act. The Commissioners still rigidly maintain that violation of the Act of Parliament, and without any necessity. The navigation channel all the way is deep enough for the steam boats without it. They refused a formal application from the landowners for liberty to put sluices in it. The evils of that illegal and unnecessary foot of height of the Killaloe weir extends up the Shannon 31 miles, and laterally along eight tributary rivers. I have seen the hay crop rotting, and the herbage on the pastures all spoiled by saturation of small floods, merely three to six inches deep, while that illegal, and quite unnecessary, extra foot height of the Killaloe weir was protected and persistently preserved by the Government Commissioners.

In response to an invitation to write a paper for your meeting, I offer this, in the hope that it may be useful to sanitary and to river engineering interests. I pledge my word for the truth of every part of this statement.

In the name of the many sufferers by the evil effects of the Shannon weirs, I earnestly implore the Society of Arts to give some attention to the very unwholesome state of the valley of the River Shannon, and to use their great influence with the Government to induce them to abate the great public nuisances they have placed there. This may be easily done in one year, by constructing six movable regulating weirs of iron and wood, in lieu of the present six wholly immovable, unscientific, and unsuitable stone weir-mounds. By their means all saturation in the valley would be directly terminated for ever, and also all flooding of roads and houses; none but great winter floods would go over the lands, and those would not rise high nor last long, and would do some good as irrigation on the meadows. No great amount of excavation is necessary to give them full effect.

ON THE WATER SUPPLY OF THE UPPER BANN RIVER, IRELAND, AND THE AMOUNT OF RAINFALL UTILISED.

By John Smyth, Jun., A.M., C.E., F.C.S., F.M.S.

It is proposed in this paper to describe shortly what has been done to conserve the surplus water supply of the valley of the Upper Bann River, the success which has attended the work, and the amount of the rainfall made available.

The River Bann rises in the Mourne Mountains, and flows in a northerly direction, passing through Lough Neagh, where it receives many tributaries, until it falls into the North Atlantic Ocean at Coleraine. Its course is 85 miles long, and its total drainage area, including the surface of Lough Neagh, is 2,345 square miles. It is thus the third largest river in Ireland, being surpassed only by the Shannon, and the Barrow Nore and Suir. The most of its branches arise at a high elevation, and have a rapid descent towards Lough Neagh, thus affording along their banks favourable sites for mills. This circumstance has been well taken advantage of by the industrious inhabitants of the district, and contributed largely, I believe, to the establishment of the linen trade in the North of Ireland. The Upper Bann, of all the branches or tributaries of the Bann or Lough Neagh drainage system, is the most interesting, as an example of the highly successful application of engineering science to the development of its natural resources. Mills existed on it at a very early date. It is said that, in 1772, there were 26 bleach mills upon the Upper Bann, and that the linens bleached therein were well known and much esteemed in England and Scotland. Previous to the year 1833, the water power of the river was made available for mill purposes, by means of wooden undershot wheels, but in that year the late Sir William Fairbairn erected the first iron breast wheel at Hazelbank mills, and thus nearly doubled the power previously obtained from the water. Other mills soon adopted the more efficient wheel, and business having increased, machinery was extended. The advantages thus gained from the water power was so great, that the desirability of extending those advantages to every season was soon seen. In the year 1835, therefore, the Bann Reservoir Company was formed, to provide a better and more regular supply of water to the mills. They placed the matter in the hands of the late Sir William Fairbairn, F.R.S., who, assisted by Mr. J. F. Bateman, F.R.S., surveyed the rainfall collecting grounds of the river, and made an excellent and most interesting report of the water-bearing resources of the district. He recommended the construction of two impounding reservoirs, Lough Island Reavy and Deer's Meadow, and one auxiliary, reservoir Corbet Lough. Lough Island Reavy reservoir was first constructed according to the plans and under the superintendence of Mr. Bateman, and was finished in the latter part of the year 1839. The Corbet reservoir was also constructed, but not to the full extent contemplated, the embankments having been made to impound only 11 feet 3 inches, instead of 18 feet depth of water. Much difficulty was encountered in the work, which was not finished till the year 1847. The Deer's Meadow was abandoned, as the works were of a heavy character; and, the gathering ground being small, it was feared there would not be enough of water to fill it. Lough Island Reavy reservoir is situated in a narrow valley on the north-east flank of the Mourne Mountains, and receives three-fourths of its supply through a conduit from the Muddock river, a tributary of the Bann, and one-fourth in the same manner from the Moneyscalp river, which does not belong to the Bann drainage area, but flows into the Irish Sea near Newcastle, about six miles from the reservoir. The water is impounded to a depth of 35 feet above the old lake, which existed there, and at top water is 430 feet above sea level, It can be drawn off to a depth of 38 feet 6 inches below top water. The area of the reservoir, when full, is 250 acres, and the capacity 270 million cubic feet. The water is discharged from the reservoir through two 18-inch iron pipes, secured in a culvert built in the solid ground beneath the main embankment, and is conducted by an open channel to a point a mile down stream, below the in-take, where the supply is lifted. After flowing down the Muddock river for six miles, the water reaches the Bann. In the first three miles down the Muddock, the descent is rapid; in the last three, however, the stream is sluggish and very sinuous, and the banks are subject, after heavy rain, to be overflowed, not only by the floods of the Muddock, but also by those of the

Bann. This result is rendered more certain by obstructions in the Bann at the mouth of the Muddock river.

These floodings, and also minor ones, caused by the overflow of some of the lands when the water is being sent down to supply the Bann, owing to obstruction from weeds and the silting up of the channel, have been the source of actions being taken against the company. This difficulty arose from a dispute as to whether the reservoir company or the riparian proprietors should cleanse the stream. The company contended that, as the river was a natural watercourse, over whose banks they had no power, and on which they could not throw out the cleansings without permission from the proprietors, they were not bound to clean out the river. The riparian proprietors, on the other hand, contended that the company had altered the flow of the stream, by impounding the water at one season and sending it down at another, that thus the stream was an artificial one, and the company were bound to keep the channel clear, so that no injury should accrue to them.

When the case was first brought before the Judge of Assize, the jury gave a verdict in favour of the company; this verdict was, however, set aside by the Court of Queen's Bench, and a new trial was granted. At the new trial the case went against the company, and on appeal to the Queen's Bench, the same was confirmed. The company then appealed to the twelve Judges in Exchequer Chamber, the majority of whom gave the case in their favour. The riparian proprietors then appealed to the House of Lords, where the case was finally determined against the company. The reservoir company, therefore, made an arrangement with the proprietors for the removal of the cleansings, and cleaned out the Muddock river last summer. The proper supply for the mills can now be sent down to the Bann without overflowing the channel, and the directors have erected a gauge weir board across the channel, at a short distance below the discharge-pipes, the better to regulate the supply sent down. From the mouth of the Muddock river to Ervin's weir, where the surplus water is lifted and taken into the Corbet reservoir, a distance of eight and a half miles, there is about 30 feet of unoccupied, and $7\frac{1}{4}$ feet of occupied, fall on the River Bann. At this weir, the caretaker daily measures the quantity of water coming down the river, and thereby regulates the amount to be supplemented by the reservoirs. The channel of the feeder from this weir to the Corbet reservoir is about a mile long, and wide enough to take in considerable floods. The area of the Corbet reservoir is about 70 acres when the water is at top level, or $11\frac{1}{4}$ feet, above the discharge outlet. The water is discharged through an iron sluice three feet wide, and capable of being raised one foot high; there are two other unused sluices of the same dimensions. The cost of these works has been about £30,000, the income is derived from a rate of £10 per annum per foot of fall, levied on linen bleachers, manufacturers, and spinners, and £5 on corn and flax-scutch millers. The fall from the outlet of Lough Island Reavy to the tail water of the last mill is 350 feet, of which, however, at present only 180 feet can be rated. The dividend has not averaged more than three per cent.; if, however, litigation ceased, and all the falls were occupied, it would pay very well. Lough Island Reavy reservoir has now been at work for nearly 40 years, and has well borne out Sir William Fairbairn's anticipations of its utility in supplying water. In his calculations he assumed the yearly rainfall at Lough Island Reavy as 36 inches, since no extended rainfall observations had then been made, and at that time 36 inches was considered the average for all Ireland. He allowed one-sixth for absorption and evaporation, and concluded there would be sufficient to fill the reservoir one and a quarter times, on the average, in the year. As I was much interested in the question of the rainfall, and the amount available for water supply, I commenced, eighteen years ago, to keep a rain gauge at Banbridge, which is about 20 miles by the course of the river below Lough Island Reavy. At the same time, too, I had one erected at Lough Island Reavy, where the caretaker took the daily observations, and forwarded them to me weekly. In the year 1874, I read a paper at the Belfast Meeting of the British Association, on the Rainfall of Ulster, for which Mr. G. J. Symons, F.R.S., furnished me with the most important statistics. In the discussion on the paper, regret was expressed that there were so few rain-gauges in Ireland, and it was resolved that observers should be invited, and gauges furnished, as far as the grant from the Association would warrant, to those who asked for them. Mr. Symons, therefore, as Secretary of the Rainfall Committee, published a letter in the Irish papers, in accordance with the resolution. I am glad to say that a large number applied—greater, indeed, than the grant could afford gauges to, and amongst them, several from the Bann Drainage District and neighbourhood, for whom, by providing a few gauges myself, I ensured a supply. Besides the two already at Banbridge and Lough Island Reavy respectively, there is one at the intake to the Corbet reservoir, kept by the caretaker; one at Kate's-bridge, two miles further up the river; one at Hilltown, about two miles up the river, above the mouth of the Muddock river; and, for the years 1875, 1876, and 1877, I employed the highest inhabitant on the Butter-mountain to keep one for me, at an elevation of 930 feet above the sea, and about three miles further up the course of the Muddock river than the intake to Lough Island Reavy reservoir. All these observers are inside the drainage area of the upper Bann river. The average rainfall for the last seventeen years at Banbridge is 31 inches; at Lough Island Reavy, 45 inches; and, for the three years mentioned above, at the Butter mountain, 83·1 inches. Since I wished to have a register of rainfall at a still higher elevation, and Mr. Crawford (one of the Directors of the Bann Reservoir Company) was anxious to know the rainfall at the Deer's Meadow mountain, the site of the reservoir not yet carried out, we jointly engaged an observer there, and removed the mountain guage from the Butter mountain to the Deer's Meadow mountain, to a point 1,050 feet above the sea level. This station was about two miles from any house, and the caretaker visited it weekly, but after three months it was interfered with, so it had to be taken up. I am in hopes soon of being able to get a man to keep the gauge at a high elevation on the other, or south side, of the Deer's

Meadow mountain. Basing our calculations on the foregoing available rainfall statistics, as the rainfall at the level of Lough Island Reavy is 45 inches, and at an elevation of 930 feet, 83 inches, it must be still more for all elevations between 930 and 1,600 feet (the highest point of the mountain). The ridge of the opposite side of the drainage area, however, is not so high, so we may assume 60 inches as the average rainfall, which is something less than the mean between the minimum elevation at the reservoir, and the maximum at the elevation of 930 feet. The drainage area of Lough Island Reavy is five square miles, and the year's rainfall would, therefore, be 697 million cubic feet. The capacity of the reservoir, filled to 38 feet 6 inches above the outlet, is 270 millions cubic feet; or, if there be no loss from evaporation and absorption, there would be more than enough to fill it twice over. I find it requires a fall of 30 inches registered at the reservoir, equal to 40 inches by calculation as above, over the whole area to fill the reservoir, from the beginning of October until the beginning of April (the season it is generally filled). As 23 inches fills the reservoir, there results a loss of two-fifths for absorption and evaporation; but as the evaporation from the surface of the reservoir is considerable, and there may be a loss at the intake from some water getting over the weir, when there is a large flood, it is more than probable two-thirds might be taken into the lake. It was, therefore, fortunate, Sir Wm. Fairbairn was so low in his estimate of the rainfall, as it is now evident he allowed too little for waste.

At the intake to the Corbet reservoir, where the drainage from 80 square miles of partly flat and partly mountainous country passes down the river, on comparing the amounts passed over Ervin's weir there, with the average yearly rainfall, I roughly calculate the former to be two-thirds of the latter, showing a loss of one-third for evaporation and absorption. In this calculation 30 per cent. is deducted from the results of the weir gaugings, calculated by the usual formula, for the roughness and uneven crest of the weir. I arrive at the value of this deduction from knowing the amount discharged from Lough Island Reavy, when the normal amount is passing over Ervin's weir, and making the same allowance for the gaugings. The amount taken into Lough Island Reavy over that discharged, and the amounts taken into the Corbet reservoir are, of course, allowed for in the above calculation. It is very much to be desired that Ervin's weir was levelled, and made of such a form, that more exact calculations could be made from the daily gaugings there.

The registries, now kept 32 years, show how useful the reservoirs have been. Lough Island Reavy has granted an average supplementary supply of one-half of the summer standard discharge for 3,123 days, or a yearly average of 100·9 days of 24 hours, and has been empty only 351 days, or an average of 11 days yearly.

The Corbet Reservoir Register has not been kept so long or as accurately as that of Lough Island Reavy. From the average, however, of three years, it has been kept compared with Lough Island Reavy, I calculate it has supplied one-half the amount, for although its capacity is so small, yet as it commands the surplus water of 80 square miles of drainage, it is filled several times in the year. Add this to the Lough Island Reavy supply, and there is a total of 150 days supply. Sir William Fairbairn calculated, that when all the reservoirs should be made (including the Deer's Meadow, and the full completion of the Corbet) there would be a supply of 60 cubic feet per second for 108 days of 24 hours each year. As about 27 cubic feet per second has been allowed for 150 days, if we reduce it to 108 days, it amounts to 37·5 cubic feet, which is very nearly in the same proportion to the amount that can be impounded as his calculation was to that proposed to be impounded. Since the supply has only failed on an average 11 days yearly, the standard water-power may be said to have been almost constantly maintained.

From calculations made of the amount of water flowing down the river at Ervin's Weir, I find there is an average of about $5\frac{1}{2}$ billions cubic feet in the year, and the normal flow kept up by the reservoirs would amount, in the whole, to about two billions cubic feet; so, as one-half the supply is not made available, there would be an advantage in constructing more reservoirs, not only at the sources of the River Bann itself and its other branches, such as the Rocky and Leitrim rivers, but at other sites along the course of the river where land is not valuable, to impound the surplus waters, as has been done to a limited extent in the case of the Corbet reservoir. Were such works carried out, about $\frac{2}{3}$ths or $\frac{3}{4}$ths of the annual flow might be conserved, and the water power not only made more valuable, but enough provided for a sanitary supply to the towns on the banks of the river, the most important of which are Banbridge, with a population of about 6,000, and Portadown, with one of about 8,000. The latter town, and the neighbouring low lands in the vicinity of Lough Neagh, have suffered much from long continued floods in wet seasons. Were reservoirs constructed on the other rivers flowing into Lough Neagh, and forming part of the general Bann drainage area, these floods would be much diminished, if not entirely prevented, for the Upper Bann's drainage area is only 134 square miles, or $\frac{1}{17}$th that of the Bann system. The largest tributary is the Blackwater river, with a drainage area of 626 square miles; the next, the Main river, with 277 square miles; next, the Balinderry river, with 166 square miles; next, the Upper Bann; and the Moyola comes very near it, with 129 square miles. It is singular that, for so far, reservoirs have not been constructed on these rivers. A consideration of what has been already done on the Upper Bann shows that much more good might have been done, and litigation prevented, had the river been under one general management, in which representatives of the different interests would have had a voice. The following interests should, I think, be represented; viz., landholders, millowners, Sanitary Boards, fisheries and irrigation. As an instance the Bann Reservoir Company, about the beginning of the year 1858, proposed to contribute largely to a scheme costing little money, by which the drainage of the River Muddock would have been much improved, and a large amount of land set free from floods, to which they were previously subject, but the landlords would not co-operate.

I hope this brief description of what has been already done on the Upper Bann river may

induce other districts more generally to adopt reservoirs, and make the water supply a source of wealth and health to each district, instead of allowing it to become injurious, both to property and health, and in many cases destructive.

The Upper Bann was formerly celebrated for its trout-fishing, which has been much injured of late by the discharge of flax steep water and other impurities into its course. Salmon are now prevented from ascending the stream by the weirs; Eels can be taken largely during the floods, but are not much sought after. Pearls have been found in rare instances in the river. Its water is exceedingly soft (about 5° by Clarke's test) and peculiarly well adapted for bleaching, which is extensively carried on in the various linen establishments along the river.

NATIONAL WATER SUPPLY.

By J. Bailey Denton.

I duly received the circular of the 12th ultimo, inviting me to attend the approaching Conference of the 15th and 16th of May, and suggesting that I should furnish some further remarks on the subject to be discussed.

The introduction of the Rivers Conservancy Bill by the Lord President into the House of Lords, and the publication of the letter addressed by his Royal Highness the Prince of Wales to the Premier on National Water Supply, would seem to render it inopportune for individuals to offer any observations on the "division of England and Wales into districts for the supply of pure water to towns and villages in each district," until it is known how far the Government will initiate, and the Legislature will sanction, the rendering the control of rivers and watercourses subservient to the more important object of water supply.

I venture to express the opinion that, at the present juncture, the only way of bringing to a practical bearing the knowledge in possession of the country, and the evidence given before the several Royal Commissions and Parliamentary Committees on the subject of our water economy in its various phases, is to impress upon the Government and the Legislature that the obligation to provide potable water of unexceptional purity for towns and villages situate within river basins, ought to precede all other considerations in relation to the improvement of rivers and watercourses, and that any action taken for their conservancy must fail in this one all-important point, if it does not proceed upon such recognition. It will be observed that in the Bill now before the House of Lords no direct reference is made to water supply, although such is the reciprocal bearing of that object upon river conservancy, that it is hardly possible to deal with one in a comprehensive way, independently of the other, without some prejudicial effect.

The timely proposition of his Royal Highness that there should be a central permanent Commission, whose duty it would be to investigate and collect facts connected with water supply in the various districts into which the United Kingdom may be divided, "in order to facilitate the utilisation of the natural sources for the benefit of the country as a whole," must, I submit, commend itself to every one as supplying, in the most tangible form, the omission of the Rivers Conservancy Bill, to which I have just referred. The suggestion is the more apposite, as it comes at a time when the larger centres of population are not only providing themselves with water to the disadvantage of small towns and villages, but are rendering unfit for domestic use—by pollution—the waters they do not appropriate.

It is an incontrovertable fact that, inasmuch as all rivers are maintained by the outflow of springs issuing from the water-bearing strata, and by the natural conservation of the rainfall upon high uncultivated surfaces, it is not possible to raise water from subterranean sources, or to intercept water from high grounds for the supply of populations, without affecting the flow of rivers and watercourses, while it is equally certain that any acts of conservancy which may lead to the more rapid discharge of watercourses descending from the hills to the valleys, will prejudicially affect the local water supply of the districts through which these watercourses pass. At the same time, it is known to those who have carefully studied the earth's stratification, that such is the alternation of pervious and impervious strata throughout this country, that there hardly exists a river basin, wherein, by special works of combination or otherwise, towns and villages may not be economically served with water without any appreciable effect upon our river systems.

What is now wanted is the record, in an intelligible form, of such hydrogeological information as is already in the hands of the Geological Survey Department, to be supplemented from time to time with additional details. This would furnish the most useful data in the hands of any Commission which may, on the suggestion of H.R.H. the Prince of Wales, be formed, and would make every one familiar with the underground sources of supply.

DOMESTIC FILTRATION OF WATER CONSERVED IN TANKS AND CISTERNS.

By J. Bailey Denton.

There is no object connected with our domestic economy which has an equal influence upon health, and which is, or may be, brought so completely under our control, as water when once delivered to the dwelling, and yet there is nothing that really receives so little attention. Impressed with this, the author is desirous of placing before the public a very simple means which he has adopted, where all the water consumed by a household for any purpose whatever may be effectually filtered, let the quantity be what it may.

For drinking, cooking, and washing of the person, including that used in baths, all water which has been in any way collected and stored in either outside underground tanks, or open reservoirs, or in inside service cisterns, to which it may have been raised from tanks and wells, should be subjected to filtration through such material as will most effectually remove from it any putrescible matter. This is necessary, for the simple reason that although water delivered into a dwelling may be perfectly pure when it first enters either the open reservoir, or underground tank, or the service cistern, it undergoes deterioration directly it is stored. If it is collected in reservoirs or tanks outside the dwelling,

sundry vegetable and animal matters are carried into them from coutributing surfaces, and when there, undergo decay and putrefaction. Leaves of trees, living insects, and excreta of birds and insects, soot from chimneys, and various other substances of organic origin, too, are invariably to be found in all these receptacles. If it is stored in service cisterns inside the dwelling, though some of these substances may be abseut, clouds of dust and myriads of minute insects rise in the air from the lower parts of all dwellings, and imperceptibly find their way through existing crevices and openings into such cisterns, and soon taint their contents. The effect of this condition on the health of those who drink stored water may be very slow where the constitution is robust, but with persons of weakly frames, and in times of illness, it must tell with certain injury.

The existence of these substances is shown in the shape of a filthy deposit, which will be found in all receptacles of stored water. A close examination of this deposit will prove it to consist for the most part of putrescible animal and vegetable substances.

To remove these drawbacks, and at the same time secure economy in the use of water, the author has devised a means by which the supply to all dwellings, whether they be the palace, the mansion, the public institution, the moderate-sized house of the middle class, or the cottage of the poor, shall uot only recover the purity it may have lost by storage, but may reach a condition even superior to that which belonged to the water before delivery. This is done by subjecting all the water used in the dwelling to filtration through carefully selected aërated material as it flows from the service cistern, to be drawn off in various parts of the dwelling. The arrangement by which the author effects this object is exhibited on the Society's premises, and is so simple and certain in the performance of its duty, that no water can be used by either the cook, the butler, the housemaid, or the scullery maid in the mansion, or by the labourer's wife in the cottage, until it has passed through the filtering material, which is kept in an aërated condition by the automatic action of the filter, in spite of any neglect on the part of servants.

The Self-supplying Aerated Filter.

The filter is fixed under the cistern of the dwelling in as high a position as can be arranged; the higher it is placed the wider its use, and the greater the benefit obtained from it. The service pipe from the cistern becomes the feeder of the filter, and there being no other water used in the house than that which has passed through it, the whole is filtered as it is drawn.

The filtered water does not occupy the same compartment as that which holds the filtering material. The two are distinct from each other. There are, in fact, two compartments, an upper and a lower one, the former containing such a quantity of filtering material as will constantly cleanse the water used in the dwelling, whatever that quantity may be, and the latter holding only so much fresh filtered water as can possibly be required in the establishment at any one time. The capacity of the lower compartment is made, in fact, to fit the actual requirements of the household.

As the water is drawn off from the lower compartment to be consumed in the kitchen boiler, or to be used for baths or any other domestic purpose, an equal quantity is admitted to the filtering material in the upper compartment. This reciprocal action is effected by the use of a ball or float in each compartment, which, acting upon a single valve, regulates the influx. By shutting off the water when sufficient quantity has passed through the filter, an interim of time is gained to effect that perfect aëration of the filtering material which is the great object in view, for it is by the aëration which follows the passage of water through the material that any putrescible matter which may exist in the water becomes oxydised, and is rendered harmless.

No filter now in existence effects these objects with the same certainty and with equal effect upon large as upon small quantities. In most filters the material is constantly under water, and, therefore, not aërated, while those which aim at aëration very imperfectly accomplish the object upon a small quantity only. In the "Self-supplying Aërated Filter," the air circulates above and below the material, and as water is 800 times heavier than air, and air must necessarily take the place of the water in the material, as soon as the water has passed through it, a constant change of water for air, and air for water, is kept up.

It was this characteristic of the filter that induced the author to christen it the "Self-supplying Aërated (Oxydising) Filter." He prescribes no especial filtrating material, but leaves the selection to be governed by the character of the water in use. He himself has found that burnt earthenware, or stoneware, such as sanitary pipes are made of, broken small into a granular condition, and mixed with clean fine sand, forms the best material for ordinary use. He uses no other, though in certain cases animal or vegetable charcoal may be superior, if it is frequently changed, and never used a second time until it has passed through the fire again.

Care should always be taken to fix the filter within ready reach, so that the material can be examined, and removed, washed, and returned, or changed for fresh material, as often as necessary.

The "Self-supplying Aërated (Oxydising) Filter" has been patented more for the purpose of securing good workmanship in its construction, and proper skill in fixing it, than for any pecuniary advantage to be gained from the patent. And it is with the object of drawing attention to an important deficiency in our ordinary domestic arrangements that this paper is read, not with any idea of promoting the commercial success of a new invention. Messrs. Merryweather and Sons, of Long-acre, are the makers of the filters, and they supply them of a size and with the material suitable for all establishments and institutions, public and private, taking care that the filtered water compartment shall be of such a size as to meet all requirements, including baths and trade uses. For trade uses and for stables, the arrangement secures the best of water without any extra labour.

The advantages of the "Self-supplying Aërated (Oxydising) Filter" are:—

1st. That at a moderate cost all the water used in a dwelling, let its size be what it may, can be filtered automatically.

2nd. That the only attention required of those who use it is to see that the ball-taps are in good working order, and that the filtering material is washed or changed periodically. In many instances a filter may be used twelve months without requiring either washing or changing.

3rd. That the filtering material can be at any time examined, taken out, washed, and replaced or changed without any difficulty whatever.

THE WATER SUPPLY OF KINGTON AND NEIGHBOURHOOD.

By G. Foote, Medical Officer of Health for Kington (Urban).

I was for nearly five years Medical Officer of Health to the Kington Rural as well as the Urban Sanitary Districts. I now hold the latter appointment only.

When I was elected to the office, in April, 1873, the water supply to the several villages was, with one exception, as bad as could be. They were mainly supplied with water from the different streams which ran through or by them, all highly contaminated with sewage and other matters injurious to health; for the privies, where they did exist, were either situated over the ditches which emptied into the several streams, or actually situated over the stream itself, and that was the case in a number of instances. The first work that was done under my advice was to remove the privies, and have the ditches cleaned out; many of them were immense elongated open cesspools. Then, to have fresh privies constructed, with dry pits, or the earth system adopted; in all cases, free ventilation was secured. Then, to have wells sunk, both public and private, wherever convenient, and so doing away with the necessity of using the water from the streams for drinking purposes. The improvement in the health of the different localities was very marked.

The exception I mentioned is New Radnor, which, though a borough, is only a village. It is situated at the bottom of a gorge in Radnor Forest, and there is a rivulet of very pure water coming down the gorge; a pipe conveys the water to some of the houses, but it is inserted into the stream below the point where it receives the sewage from several cottages. The stream continues its course through the borough, and the water becomes more and more impure; but it is used freely for drinking purposes. Yet New Radnor was better supplied with fairly good water than any small town or village in the rural district. I proposed to make it perfect, which could have been done at a small cost. If the water were intercepted by a pipe, inserted some 150 yards higher up the gorge than it is, where the water is free from any contamination, and then conveyed to the top of the town, where a reservoir could have been constructed, perfectly pure water would have been conveyed to any part of any house in the borough by a continuous service. The plan was steadily and successfully opposed, and nothing has been done in the matter all these years.

In Kington, which is a small town of 2,000 inhabitants, there is a spring of exquisite water issuing from an opening in the rock at the base of Bradnor Mountain; a pipe conveys the water, which is forced up by a wheel-pump turned by water-power, to a tank situated at the highest point of the town near the church, whence it is conveyed by a continuous service to a part only of the town. The other houses are supplied from wells, the water from which is always more or less contaminated, especially so in some streets, as there are a number of cesspools in all directions.

There is enough water in the Radnor spring to supply a town three times the size of Kington, and I have for years endeavoured to persuade the town Commissioners to buy the water-works, and form large reservoirs for the benefit of the whole town; my proposal has never been approved, and last year a poll was taken, and the inhabitants, by a large majority, decided to have nothing to do with the scheme. Thus, in two places, Kington and New Radnor, which are exceptionally favoured by nature in the supply of exquisitely pure water, a large portion of the population refuse to avail themselves of it, preferring, for the sake of economy, using water sure to be more or less contaminated.

I have now stated what has been accomplished for securing good and wholesome water in this sanitary district. From my own experience, I do not think that small towns or villages should be supplied with water, which has been collected into a reservoir from the neighbouring district, either from one streamlet or many. Unless it could be carried direct from its source in a pipe to the reservoir, no streamlet can be free from matters injurious to health; it receives all the surface drainage from the fields, saturated with manure of various kinds; and, in the majority of instances, the drainage also from cottages, with the foul matters from piggeries, &c., and I do not believe in any method yet discovered by which water so contaminated could be filtered, so as to render it in any degree pure.

In nearly every village or its neighbourhood, well water can be obtained, and if there are no cesspools permitted within a certain area, the water, if the well is of any depth, is sure to be pure, as the earth itself is the only natural and pure filter.

When required, well water can be easily stored in a tank by a little mechanical contrivance, and so a continuous supply maintained.

SUGGESTIONS OF A STATE RECORD OF THE SURPLUS WATERS FLOWING FROM HIGH AND UNCULTIVATED LANDS.

By Charles Slagg, C.E.

Further facilities ought to be given to the sanitary authorities of small towns for combining to obtain the best supply of water within their reach and resources. When the sanitary authority of a small town calls for a report on the best means of procuring a supply of water, the engineer called in finds—or may, and in fact often does find—that his instructions are too limited to enable him to propound the best scheme, in point of quality, quantity, and economy of working. There are, in numerous instances, several small towns lying near together which have no supply of water, and

which have separate sanitary authorities. Moreover, there may be, at no great distance from these small towns, a larger town which requires a further supply of water, or there may be—and in fact in one instance at least there are—two such towns.

To confine my remarks to cases within my own knowledge, there are three separate local authorities in a district comprised within a length of five miles and a breadth of two and a half miles, the aggregate population of which is 25,000. In this district there is no supply of water. At a distance off, there are two towns of a population of 40,000, taken together, and in each town the supply of water is very inadequate, the one in point of quality and the other of quantity.

Taking first the three smaller towns, each has its sanitary authority, and each has called for a report on the water question, there having been made three reports by different engineers. The instructions to each being limited to the requirements of the one place, the engineer finds it impossible to do more than recommend the best of the sources in the immediate neighbourhood, whereas, if anyone of the engineers had been consulted jointly by the three Boards, he would probably have recommended a better plan in respect of the three requirements of quality, quantity, and economy of working.

If we now take into consideration the two larger towns also, both of which are seeking means of improving the water supply, but neither of which can do so from the present sources, there appears a further reason for a combination of towns for this purpose.

There is a range of hills the surplus waters of which would afford an ample supply to all the towns by gravitation. The distance is certainly considerable, but it would probably be found not too great for economy in a combined scheme. But when each authority considers its own scheme singly, it seems preposterous to go to such a distance, and, each authority acting without reference to the others, no one investigates the capabilities of the larger and better source.

What, then, ought to be done in all such cases? It should be, if this Conference think well to recommend it, that the utmost capabilities of all such sources to afford a supply of water to towns be investigated and declared. Then each separate sanitary authority would know how much water is within its command, and if, knowing these capabilities, the engineer should advise that it would be economical to make joint works, each authority would add to its share of the cost of the joint works that of its own service reservoir, branch main, and town piping.

An analogous precedent for such a record is the census of the population. When we want to know the population of a place, we do not, individually, count or estimate the number, but turn to the State record. So should it be with water. The capabilities of every area of high ground to afford water for towns should be recorded, both as to quantity and elevation, and all proper sites for storage reservoirs should be investigated, and measured as to their possible contents.

Some of these areas of high ground are already appropriated to existing supplies of water, but many remain unappropriated, either wholly or in part.

"ABYSSINIAN" TUBE WELLS.

By Robert Sutcliff.

The process of obtaining water by digging wells is of great antiquity, and that of boring scarcely less ancient. The particular method of obtaining water that it is the object of this paper to explain, is entirely modern. The crude idea of driving a tube into the ground for water is scarcely more than a dozen years old, and many of the appliances for driving tube wells are still more recent. In ancient days, wells were national property, and battles of possession have been fought over them. Now, a well can be made in many places in a few minutes, and the very deserts may be tapped, and clear springs obtained from them. Like many other clever inventions, the tube well owes its first existence to America, although it has been jocularly claimed as having been really originated by the negroes, who drove pointed bamboo canes into the earth, and slaked their thirst by drawing up the water through the pores of the cane. Be this as it may, the first iron tube wells could only be driven in the very softest soils, and the tubes were struck on the head, which caused bending, injury to the screw threads, and fracture of the pipes. The pipes at first employed were also of inferior quality, such as are used for gas purposes, and were quite unsuited to the rough treatment and vibration that a tube well is subjected to. Upon the introduction of the patent into this country, the necessity for an improved method of driving the tubes became at once evident to those having charge of the invention.

This process it may be of interest to describe. In the first place, the materials used must be of the very best quality, and specially tough and good iron is required for the tubes. The first tube is pointed and perforated up for a few inches, with holes varying from one-eighth to quarter inch. The point is somewhat bulbous, but only sufficiently so to make clearance for the sockets by which the tubes are connected together. On the tube a clamp is fastened, provided with steel teeth, so as to grip the tube. This clamp is tightened by means of two bolts. Next, a cast-iron driving weight, or monkey, is slipped on to the tube, above the clamp. The tube, thus furnished, is stood up perfectly vertical, in the centre of the tripod; ropes are made fast to the monkey, and driving is commenced by two men pulling the ropes, and allowing the monkey to fall on the clamp. It is particularly important that the bolts of the clamp are kept tight, so that no slipping takes place. When the pointed tube has so far penetrated the earth that the clamp reaches the ground, the bolts are slackened, and the clamp raised again some two or three feet. Length after length of the tube is thus driven into the earth, being connected together by socket joints. It will be noticed that the tube well proper is, therefore, self-boring, and that no core of earth is removed.

One of the first questions that will suggest itself to a thinking mind is, will not those small perforations be blocked entirely up by being thus forcibly driven through the earth. This was the American's first idea, and he provided a sort of sleeve, in the shape of a sliding tube over the perforations, to

protect them from the earth. Experience, however, has proved this protection to be quite unnecessary. The perforations are made about four times as numerous as is necessary for obtaining a full flow of water from the tubes. Earth does find its way into the tube-well in pellets, like the casts from a worm; but some of the perforations are always left sufficiently open to allow water to pass into the well, and if the soil comes rapidly into the tubes, it is easily mixed with water poured down from the surface, and drawn up by ½-inch tubes, to which a pump is attached. To thoroughly clean and open the perforations, an ingenious contrivance has, however, been utilised. Long before the tube wells were invented, a pump was manufactured that, by lifting the handle, would allow the water to run out of the tail-piece, and thus prevent freezing in winter. This sudden liberating of a column of water that is maintained above its normal level, is the method which is employed to clear out the perforations of a tube-well. In skilful hands, the water can be kept in a state of agitation, being alternately allowed to press through the perforations, from the inside and from the outside; and before the whole column of water has descended to the level of the spring, it is caught up by the pump, and a fresh supply drawn into the tube. In this way the perforations are syringed, as it were, free from all soft obstructions, and the excess of holes over what is required, makes the closing of a few by grit which is too large to pass through, of no consequence. This action of the pump is not only useful in clearing the perforations, but in some soils it plays a most important part in the development of a supply. When all the holes are free, the fall of the column causes jets of water to disintegrate the earth, and by this means the finer and softer particles are pumped to the surface, and either an actual cavity is formed below, or, in gravel, a sort of filter bed is left, out of which all the sand within reach of the pump has been withdrawn. It should be stated, that the first presence of water in a tube-well is ascertained by an ordinary plumb-line, which is also useful for gauging the quantity of earth in the tubes. Having got the tube-well into the spring from which it is to draw the perforations all free, and the earth thoroughly disintegrated in the immediate neighbourhood of the point, it remains to describe the method of pumping.

Until this plan of obtaining water was discovered, all pumping was done by means of a suction-pipe communicating with the well or bore-hole. As the atmosphere had free access to water in the well, the action of the pumps was simply to draw water out of the reservoir, and there its duty ended. The method of pumping a tube well is entirely different; all atmospheric pressure on the water in the tubes is removed at each stroke of the pump, and hence the supply is drawn to the spot, instead of simply flowing there by gravitation. Although the tube wells achieve this result as it were by accident, the importance of the fact is now generally acknowledged by engineers. Many engineers were of opinion that it would be impossible to obtain water at all, if the atmospheric pressure were excluded from the well, but they did not pursue their reasoning quite far enough. It is true there must be atmospheric pressure somewhere on the water that we pump from, but it need not be in the immediate vicinity of the well. Perhaps it is miles away. Pumping in this way, we have not the tiny reservoir of an artificial well, but in some cases natural underground lakes, one might almost say, seas of water, to draw from. Some here may recall how our army, during the Abyssinian war, was supplied with water by these tubes, and it was the prominence which that war gave to the invention that led to the present prefix to their name. For campaigning purposes the wells were only used singly, as one or two were found sufficient to supply the wants of a number of troops. When however large supplies for manufactories, towns and villages were needed, a fresh development in the system took place. Instead of single wells of great diameter, groups of moderate size were driven and coupled together by horizontal mains, so that powerful steam pumps could draw from many wells at the same time. The great friction that would be caused by drawing an enormous body of water to a single spot is thus avoided. Wells so coupled draw from a very large area of ground, and the water-level at any one spot is not so rapidly lowered. The very action of the pump, too, in drawing the water to the wells, opens and maintains channels of communication which help to keep up the level of the water. In putting down plant for a large supply of water, a trench hundreds of feet in length, and some two or three feet in depth, is dug, and tubes are driven every twenty-feet, and coupled by mains as already described.

It may be interesting to refer to some particular instances, where large supplies of water are thus obtained. At West Thurrock, in Essex, a cement company is pumping from two 5-inch tube wells, about 80 feet deep, 220,000 gallons per day of 10 hours. Another cement works at Northfleet is pumping 60,000 gallons per day. These have been pumped daily for about four years, and still give a constant supply. As expense is an important feature, it may be mentioned that the cost of these did not exceed £60 each. The coupled tube wells are to be found in greatest numbers at the centres of beer manufacture, where abundance of pure and cool water is an absolute necessity. At Burton-on-Trent, about two million gallons are pumped daily from these wells.

A feature of particular interest to this Congress is the question of purity of water supply. Tube wells very soon attracted the attention of sanitarians, from the fact that, being forcibly driven into the earth, there is little or no possibility of their being contaminated by surface drainage. Too frequently a dug well, from defective steining or other causes, becomes little better than a cesspool. It is also often expensive work to dig through water which is impure, in search of pure springs below, and still more costly, when the good water is found, to keep the bad from mixing with it. Accidental and temporary contaminations are not infrequent in dug wells. One of recent date came to the author's knowledge, which was of so serious a nature, as to cause a Government inquiry. It was found that in a certain district, supplied by a water company, enteric fever was raging with great virulence. No less than 352 cases occurred in places supplied with this particular company's water. In a very exhaustive report to the Local

Government Board, it was clearly proved that a contamination of the wells, caused in a peculiarly offensive and direct way, was the origin of the epidemic. The instances of tube wells having been driven through contaminated water, and tapping pure springs below, are very numerous. A few may be mentioned, where the results are not merely one of opinion, but are proved by analysis. At Gravesend, within a stone's throw of the Thames, a 2-inch tube was driven through contaminated water, and reached a spring at about 50 feet, from which a sample was taken, and submitted for analysis. The analyst, after enumerating the particular constituents of the water, pronounced it to be the purest he had ever analysed, with the exception of Loch Katrine. Bear in mind that this was taken from a well situated in the last place one would expect to find pure water, namely, within a few yards of the River Thames, which at that point is quite salt, and charged with London sewage. A point has sometimes been raised, as to whether water obtained from such positions is likely to remain pure when regularly drawn from, and, perhaps, severely taxed. This particular well has been made between four and five years, and subsequent analyses have proved the maintenance of its good qualities. It is used for purposes which necessitate a very strict watch over its excellence. The ships at that port fill their store tanks from this well, the Royal yacht among the number, the quality of the water is not therefore taken for granted.

At Deal, another illustration of the perfect isolation of a spring was afforded. Most of the wells in that neighbourhood are brackish, and a supply of fresh water was needed for a flour-mill and for domestic purposes. Within the first 25 feet water was found in gravel, but too salt for use. The miller was under the impression that if the tubes were driven deep, fresh water would be obtained, and he discouraged any further testing of the water on account of the delays in so doing, until 100 feet had been driven. At 117 feet the pump was again applied, but instead of being better, the water was as salt as brine. The engineer having charge of the work noticed that at the depth of 45 feet the water level differed both from that at 25 and that at 117 feet, and the fact suggested to his mind the desirability of testing the quality of this middle spring. A second tube was therefore driven to 45 feet, and from it quite fresh water was obtained. This happened five years ago, and the water still remains free from brackishness.

Hundreds of other instances might be mentioned, but these are so marked as to be sufficient for the purpose of illustration.

Some waters of good quality, but containing sulphate of lime, &c., are much injured by the exposure they get in ordinary wells, and the author has heard of dug wells at Burton-on-Trent that emit an unpleasant effluvia, and get unfit for use if not constantly pumped. This appears, therefore, an additional reason for keeping the atmosphere from the spring.

When rock, solid stone, or incompressible clay is met with, a tube cannot be driven through it without first making a hole, and removing the cores. In some cases, however, there may be many feet of loose earth which can be easily driven through; this (especially if gravel has to be passed through) is a tedious process. The tubes, therefore, may be fitted with a temporary hard wooden point, which will allow them to be driven through the soft earth, and when an obstruction that cannot be penetrated is met, the point is knocked out, and, being wood and in sections, it floats to the surface of the water, and leaves an open-ended tube, through which ordinary boring tools can be passed to chisel and break up the rock. A tube can frequently be driven through gravel and clay to a depth of, say, 70 feet in a single day. To bore to the same depth in similar stratum frequently takes ten days or a fortnight. The saving that may be effected by driving through the loose stratum can, therefore, be readily appreciated, and, what is still more important, the upper part of the tubes are fixed more tightly in the ground than if a boring had been made to receive them. In some cases, however, hard strata come right to the surface, and the boring operations, consequently, cannot be deferred. When this is the case, instead of using a pointed tube, an open-ended steel shod pipe is driven into the hole as the boring proceeds. As the tools pass down inside the pipe they do not cut so large a hole as the outside circumference, and some little trimming down of the sides is left for the steel shoe to perform.

In great depths the single tier of pipes, with which the work is commenced, cannot be forced the whole way. Tubes, therefore, of smaller diameter are inserted; but, as to pump by the tube well method, air-tight joints are absolutely necessary, the final tube is continuous from the deep spring to the surface. In this way, tube wells 300 and 400 feet in length are put down, and if the spring, when tapped, rises to the surface, or within, say, 25 feet of it, only an ordinary lift-pump is required to obtain the supply. Where the water does not rise to the required height, a deep well pump can be lowered into the tube well, and worked by rods from the surface.

Bored tube wells are frequently put down in sets, and connected by horizontal mains, where large supplies are required.

The new water-works at the town of Skegness, in Lincolnshire, will be supplied by two bored tube wells thus coupled together. These wells are already completed, and a supply of pure water from the sandstone has been obtained, although salt water was passed through during the upper portion of the work.

In describing the method of driving tube wells in the commencement of this paper, mention has not been made of the latest system, which is more particularly applicable to tubes of large size. It is so simple as to merit a brief notice. An elongated cylindrical weight passes down inside the tube, and the blow, instead of being struck at the surface, is delivered where it is wanted, near the point which penetrates the earth. As water in the tube would impede the force of the blow, the first socket above the perforations is made sufficiently long to admit of a stout iron ring or washer being placed in the centre of it, in such a way that the two lengths of tube, when screwed tightly together, butt against it, one on the under and the other on the upper surface. The interior of this ring is of sufficient size to allow the water to pass freely through it, but it has a screw thread

cut throughout its whole length. During the operation of driving, the opening in this ring is closed by a steel plug, which is screwed down into it until its shoulder butts on the ring. The upper surface of the plug forms an anvil, on which the driving weight falls. The plug is readily removed and brought to the surface when the required depth has been reached.

The object of this paper has been to describe a particular method of obtaining water in large quantities, and free from contamination; but in the great question that this Congress is considering of National Water Supply, no one system can, under all the varying circumstances, be applicable. One town may have abundance of good water at its feet, others may have to seek it and conduct it from a distance.

The collection of full information on this part of the subject is of the greatest interest and importance, and before a really national scheme of water supply is entered upon, it seems advisable that a complete hydrogeological survey of the whole country should be carried out.

Mr. Joseph Lucas, has, for some time past, devoted special attention to this branch of geology, and has, single-handed, mapped out certain districts, and compiled much information into a compact and useful form. To carry out such a gigantic inquiry in a reasonable time, however, requires more assistance than a private individual can generally command, and, probably, it is in this direction that Government aid might, in the first instance, be most advantageously directed.

MISCELLANEOUS.

POST-OFFICE SAVINGS BANKS.

Mr. E. W. Harcourt, M.P., made the following remarks on the need of increasing the number of Post-office Savings Banks, in his speech in the House of Commons on the proposal to vote £123,944 to meet the loss arising from the management of the "Savings Banks" and "Friendly Societies" Funds:—"All those who take any interest in encouraging thrift amongst the working classes, must thankfully acknowledge that the Post-office Savings Banks are doing a great work in the country. What we wish to argue is that that work is capable of great extension. The Post-office authorities have laid down that Post-office Savings Banks can only be established where money-order offices exist. The consequence is that many places are permanently excluded from the benefit of Post-office Savings Banks. It would be impossible now to enter into any general statistics, but I will take the example of Cambridgeshire, which represents a fair average of the counties in England. In this county we find that there is a Post-office in every seven square miles, and a Post-office Savings Bank in every 22 square miles; that the places where there are Post-offices and no Post-office Savings Banks are as 81 to 38, rather less than two to one; that is to say, that one-third of the population are without Post-office Savings Banks. In 51 places there are no Post-offices, and the ratio of persons enjoying the advantages of Post-office Savings Banks are as 11 to 7. 117,095 persons have Post-offices and Post-office Savings Banks; 58,338 have Post-offices, but are from one to six miles from a Post-office Savings Bank; 16,600 have no Post-offices, and are from one to six miles from Post-Office Savings Banks. The sizes of places having post-offices but no Post-office Savings Banks vary very much, and two may be named which, having populations each of over 2,000 people, are four and six miles respectively from Post-office Savings Banks. Many places also with Post-offices are smaller than those without them. I am well aware that the objection taken by the Post-office is a financial objection, and they say they are perfectly satisfied with the supplementary work which is being done for them by the public. The remedy, I take it, for the financial difficulty is to be found in the employment of peripatetic officials. An office where a Post-office Savings Bank exists might send out to villages within a certain radius, one evening in the week, a clerk, at a small additional pay, to conduct the savings bank work for a couple of hours; and I think in localities where the want of such a convenience is felt, persons might be found who would be willing to guarantee any extra expense for the first year or too. I know I shall be told that the Post-office has already tried the experiment of peripatetic officials, but I contend that their experiment was no fair test; it was only made for a short time upon a shifting population of navvies, and we all know that habits of thrift take time to grow, and I think the experiment was worthless. Where the object is to encourage thrift the means must be taken to the very doors; those who know anything about it know that the poor will not trudge 3, 4, 5, or 6 miles after it, particularly when that very attractive mode of investment, the public house, is so close at hand. The Post-office can and ought to open a Post-office Savings Bank wherever a Post-office exists. The assistance to local penny banks given by the Post-office can only be looked upon as a makeshift; such is the system of registered letters, whereby sums may be transmitted to distant Post-office Savings Banks. This does nothing to improve the security, and I hold that the Post-office is bound to give to investors that security which no private enterprise can offer. The issue of invitations to invest by the Post-office is well intended, but the fact is that villagers seldom read such documents, and still less seldom are influenced by them. It is impossible for me now to open the whole question of Post-office Savings Banks. Many improvements are urgently required, but at present I shall content myself with urging the one point respecting the opening of Post-office Savings Banks wherever Post-offices exist. I am well convinced of the possibility and expediency of this measure, and if I do not now succeed in convincing the Postmaster-General, I do not despair of doing so at some future time; at any rate, my efforts will not cease until I have obtained my object."

SCHOOL OF PRACTICAL ENGINEERING.

On Saturday morning, the 9th inst., Captain Douglas Galton distributed certificates to the successful students of the Crystal Palace School of Practical Engineering. This school (says the *Times*), which is somewhat singularly situated in the south tower of the Palace, was established nearly seven years ago for the purpose of giving practical instruction in the rudiments of the profession and in the manipulation of materials, so that, on entering an engineer's office, the pupil may be at once useful to his principal, from having mastered the elementary details. The alphabet of the profession—mechanical drawing, pattern-making, and foundry work, fitting and smith's work—is taught by a practical course, and may be supplemented by instruction in the civil engineering division. There is also a colonial section, for the benefit of intending explorers and settlers in uncivilised places, and in which the students learn the construction of nearly all the appliances they may need, from an artesian well to a horse-shoe. The report of the examiners for the summer term having been read, Captain Galton, in the course of his

address to the students, said that the question of English technical education was most important. Great improvements had been made by Continental nations lately in the manufacture of machinery, and had been due mainly to the care with which they fostered technical education. The question how far we should be able to hold our own in the struggle for industrial ascendency largely depended on our success in the same educational work. The artisan necessarily looked to precision, but the mechanical and civil engineer was under the further necessity of applying the knowledge of physical science to the conveniences of daily life. The course laid down at the school showed the vastness of the field of knowledge open to the practical engineer. Professor Huxley had said that success in life depended on industry and a good stomach; but to those two conditions he would add, in the case of engineers, a third—namely, the habit of observation. In their profession no fact was too small to be important. An engineer's education was always progressive, in consequence of our daily increasing knowledge of physical science; but whatever the extent to which it ought to be carried, it should always be exact. No one had done more to make practical engineering exact than Sir Joseph Whitworth. Errors and inaccuracies of construction which had formerly been regarded as trivial, had been shown by him to be matters of primary importance in machinery; and, indeed, in respect of careful and minute measurement, the productions of his works approached as nearly as possible to mathematical and theoretical correctness. Such were the elements of success in engineering; not fortune or undisciplined genius, but knowledge, industry, observation, and accuracy.

ECONOMIC ENTOMOLOGY.

A valuable "Collection illustrating the Injuries to Garden and Field Crops, Pasture Lands, Timber Trees, and Grains, resulting from the attacks of destructive British Insects, exhibited by W. S. M. D'Urban and the Misses E. A. and G. Ormerod," was recently shown at the Exeter meeting of the Bath and West of England Agricultural Society. The *Entomologist* describes it as somewhat after the type of the instructive but incomplete collection in the Bethnal-green Museum; the arrangement, however, is different, for here the more natural grouping of the insects injurious to certain allied plants, crops, or productions is followed, entomological classification being altogether ignored. The collection is intended to be thoroughly practical in its teaching, and is well illustrated with specimens of insect ravages, or, where these are difficult of preservation, by beautiful models or illustrative vignettes. Although only commenced last autumn, it is already well spoken of, but help is asked for its future development; this, doubtless, will be forthcoming, and when located in its permanent resting-place of the Devon and Exeter Albert Memorial Museum it will form a fitting type of what ought to be in every local museum in the kingdom. Members will remember that this subject was brought under the notice of the Society in June, 1877, when a paper was read by Mr. Andrew Murray on the question of the extirpation of injurious insects. The paper was printed in the *Journal*, vol. xxv, p. 734.

FOREIGN COMPETITION IN THE HOME MARKETS.

The *Economist* publishes a table from the newly-issued report of the Commissioners of Customs, which shows the value of the principal articles of foreign manufacture imported into this country in each of the last five years. Compared with those of 1874, these imports in 1878 show an increase in value of £7,795,000, or about 19 per cent., and, as prices have fallen greatly in the interval, the increase in quantities, which is the true test, must be much larger. The growth is chiefly in cotton goods, which have risen 66 per cent.; and in woollens, in which there is a rise of 34 per cent. As regards cotton goods, the increase is chiefly in the imports from Holland, which have advanced from £206,000 in 1874 to £731,000 in 1878, while in woollen goods it is mainly in the supplies from Holland and France that the growth is slow. From the former of these the imports rose from £429,000 in 1874 to £1,325,000 in 1878, the increase in the imports from June being from £2,990,000 in 1874 to £4,061,000 in 1878. In reviewing these figures the Commissioners conclude that there is nothing in them to excite serious apprehension. The value of imports of this class, it is pointed out, is very small when considered in relation to its power of displacing or competing with the like productions of this country. But, nevertheless, it is well, more especially when the simultaneous decline in the exports of this country is considered, that this expansion of foreign imports should be kept in view. It shows that foreign competition is a real and actively aggressive force, which it would be unwise to ignore, and which must be met by persevering efforts on our part to cheapen and improve production.

CORRESPONDENCE.

LONDON WATER SUPPLY.

As a member of the Society of Arts of 49 years' standing, I venture to send some remarks upon the meeting on the subject of the water supply, held at Exeter-hall on Wednesday last, 6th inst., as I had no opportunity of stating my views there.

Cardinal Manning said, that in the year 1849, there appeared in the *Times* a paragraph so strongly denouncing the water companies that he would not even venture to quote it, and that we were still in the same position. Now, as in my letter to the *Times* in 1849, I showed that at that time 70,000 houses and upwards were unsupplied even in the ordinary objectionable method by the water companies, I ask has no improvement been made during these thirty years in this and every other respect by the New River Company, the Grand Junction, the Kent, and every one of the water companies? Have not larger heads of water been constructed, more water obtained from artesian wells, and immense filter beds constructed? Is it not the case that the companies have been entirely placed under the control of the Local Government Board, first under the Board of Trade, by Acts 1852 and 1871, then by a subsequent Act transferred to the Local Government Board? Has not all public inquiry on the subject proved the present water supply to London to be good and improving?

This is shown by the Scientific Commission of 1850, report of Messrs. Hofmann and Blyth in 1856, report of Select Committee in 1867, report of Royal Commission in 1869, reports of water examiner under Metropolis Water Act of 1871, and lastly, report to Association of Medical Officers of Health in 1878 by Dr. Meymott Tidy, who sums up the question in this way:—"I am, therefore, fully prepared to endorse the high opinion entertained of the wholesome quality of the water supplied to London, as expressed in the reports of the Scientific Commission of 1850, the Select Committee of the Royal Commission on water supply in 1869, all specially appointed to investigate the quality of the water supplied to the metropolis."

If, therefore, in 1867, the Select Committee of the House of Commons were, as they reported, satisfied that both the quantity and quality of the water supplied from the Thames was so far satisfactory that there was no ground for disturbing the arrangements made under the Act of 1852, and that any attempt to do so would end in entailing a waste of capital, and an unnecessary charge upon the owners and occupiers of property in the metropolis, *a fortiori*, they would be satisfied now.

Then, again, the Registrar-General, in the report for 1877, wrote, "London maintains its position as the healthiest city in the world." In 1878, he wrote, "the low mortality of London, if we take its density into consideration, is still more striking than its magnitude."

During the last 30 years great strides, in a sanitary point of view, have been made by the establishment of public baths and washhouses, and, through the medical superintendence of all the various Vestries and District Boards, water supply has been insisted upon and provided throughout the metropolis, and I have never known the water companies fail in an adequate supply for all public and domestic purposes; and this is done at an average rate, at the present time, of 8½d. in the pound.

The law, as it now stands, fully empowers the metropolitan authority, not only to require constant supply wherever they think it expedient, but also to provide and control the hydrants required for a perfect fire-supply system, as reference to Metropolitan Act, 1871, and the Fire Brigade Act, 1865, will show. The Corporation of the City of London have removed the common fire plugs throughout the City, and provided hydrants thoroughly accessible. The rest of the metropolis, in consequence of no action having been taken on the part of the Metropolitan Board of Works, remains *in statu quo*.

One of the savings, as stated by Mr. Chadwick, by taking the water companies into the management of his Commission would be this—that the large amount now paid by the several companies to parish rates would be saved; this I believe to be a fallacy, because what is taken from Peter would have to be paid to Paul. Now, in regard to Mr. Bateman's assertion as to the cost of altering the fittings from the intermediate to the constant supply, that they need not exceed 15s. for each house. This is simply an assertion, which I, as a practical plumber of 50 years' standing, challenge him to prove. It is well known in Shoreditch, Hoxton, and in fact everywhere that the householders have been called upon in London to effect the change, the expense has been more like three to eight pounds per house, and there are houses in London where more than double that amount would be required to be expended under the constant and high pressure supply system.

It would be well if the delegates from the different parishes went to see the various water companies' works, and gathered together information regarding the magnitude of the undertakings to supply four million of inhabitants with what they could not do without for even a single day, and also searched out the various hardships and communicated with the officials on the subject.

In 1849, when the Trafalgar-square well was sunk, and an attempt was made to persuade the different parishes to forsake the water companies, I was able to convince, first of all, the parish of St. Martin's-in-the-Fields, and then other parishes, that no sufficient water supply could be obtained by sinking wells in London. I found that at that time 176 deep wells existed, and now it is acknowledged that under the London clay the chalk basin scarcely suffices to supply the different pumping apparatus at work in the district. It has also been proved that the chalk basin is the only reservoir to be depended upon—that nothing is to be got by boring through it, as evidence Meux's well, and also the large well recently sunk by the New River Company at Turnford, in Hertfordshire, adjoining the rosary ground of Messrs. Paul and Son, of Cheshunt.

Water may be obtained from the chalk basin at points yet to be discovered. Let engineers find out these sources of supply, and I feel persuaded every one of the companies will at once take to the purer sources and abandon the doubtful ones.

David G. Laing.

2, Duke-street, Adelphi, 9th August, 1879.

GENERAL NOTES.

British Association at Sheffield.—Professor Ray Lankester will lecture on "Degeneration," on Monday evening, August 25th, in place of the Rev. W. H. Dallinger, whose discourse on "The Life Histories of the Minutest Organic Forms" was previously announced. The first general meeting of the association will be held on Wednesday, August 20th, when the newly-elected President, Dr. Allman, F.R.S., will deliver his address. Full particulars of the arrangements were given in the *Journal* for May 30th last.

Hall-marking.—A committee of the Glasgow Goldsmiths' Company have lately reported concerning hall-marking and the laws affecting the gold and silver trades. They recommend (1) that in the event of the abolition of the duty on silver, the duty on gold should also be abolished; (2) that licenses for permission to deal in articles made of these metals should be abolished; (3) that the system of compulsory hall-marking should be replaced by arrangement for voluntary or optional hall-marking, because the first use of the hall-mark is really to register the fact that the duty upon the article so marked has been paid; (4) that all old Acts affecting the trade regarding duties, licenses, compulsory hall-marking, &c., should be abolished; (5) that any Bill providing for such changes should also provide for a drawback on duty-paid stocks in hand.

The Electric Light.—Some time ago, says *Engineering*, we gave a *résumé* of Mr. Keate's report on the working of the electric light on the Thames Embankment. We think that if a fresh report were issued it would be found that the cost of the electric lighting on the Jablochkoff system would be reduced to nearly that of gas. A great deal of the success here, as we have before pointed out, has been due to the excellent performance of Messrs. Ransomes, Sims, and Head's engine, which is of 20 horse power nominal. When the engine was put down last year it drove 20 lights, indicating about 23 horse power, and burning about 3·8 lb. of coal per horse power per hour. Later on 20 more lights were added; the engine then gave out about 38 horse power indicated, consuming about 3·2 lb. of coal. About a fortnight ago an exhaustive experiment was made with three sets of Gramme machines, giving light to 60 lamps, and covering a circuit of nearly a mile and a half. The engine was found capable of driving the increased number of machines without the least difficulty; the 60 lights burned more steadily than ever, and the indicated horse power developed was about 58. We do not think the consumption of coal for driving these 60 lights will exceed 3 lb. per indicated horse power per hour, and as the general working charges would not be much more, if any, than those incurred in working the 20 lights, of course the comparison between the cost of gas and that of the electric light will now come out much more favourably for the latter than before.

NOTICES.

NATIONAL WATER SUPPLY, SEWAGE AND HEALTH.

The report of the Conference held in May last is now ready, and can be obtained at the Society's House, price 1s. 6d. paper, 2s. boards with cloth back.

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FRIDAY, AUGUST 22, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

GROSVENOR HOUSE.

The Duke of Westminster is desirous that designers, artisans, and the like, employed in any branch of Art applied to productive industry, should have the opportunity of inspecting Grosvenor House, with its Works of Art, daily, including Sundays, during the months of August and September, 1879, from 2 p.m. to 6 p.m. He regrets that, for want of room, he cannot extend the admission beyond the persons specified.

A number of tickets of admission have been placed in the hands of the Secretary of the Society, for distribution among persons answering to the above description.

Such persons can obtain tickets on application at the Society's house, by bringing with them a paper containing their names, addresses, and occupations.

Each ticket admits a party of four.

There will be no admission on wet afternoons.

CANTOR LECTURES.

DWELLING-HOUSES: THEIR SANITARY CONSTRUCTION AND ARRANGEMENTS.

By Prof. W. H. Corfield, M.A. M.D. (Oxon).

Lecture VI.—Delivered March 24.

Water-closets, Sinks, and Baths.—Arrangement of Pipes, Traps, &c.

Water-closets.—The simplest form of water-closet is the common hopper closet, consisting of a conical basin with a stoneware syphon trap below it. There is nothing to get out of order in these closets, but they are liable to get stopped up through an insufficient amount of water being used in them, and the basins often get very foul from the same cause, and from the fact that no water remains in the basin. They are very often supplied with water by means of a $\frac{3}{4}$-inch service pipe, which cannot supply enough water to flush them properly. This pipe is frequently taken directly from a cistern supplying drinking water, or, even where the water service is constant, directly from the main water pipes provided with an ordinary stop-cock, or, perhaps, with a screw-down tap—a very mischievous plan, as the taps are frequently left turned on, and the water allowed to run to waste, sometimes emptying the cistern, and allowing foul air to get into it. When such pipes are taken direct from the main, the results are even more serious, as, if the water is, for any reason, turned off in the latter, foul air, and even liquid and solid filth, may be soaked up into the water mains, and contaminate the water supplied next. To this cause a very serious outbreak of typhoid fever in Croydon has been traced by Dr. Buchanan. The supply pipes for these closets should not be less than $1\frac{1}{4}$-in. in diameter, and should not be connected directly with the drinking water cistern or with the main water-pipe, but with a water-waste preventing cistern holding two or three gallons—the quantity required to flush the closet. I have here several specimens of such cisterns, lent by Messrs. Hayward, Tyler, and Co., and by Messrs. Tylor and Sons. They are supplied from the nearest water cistern, or, in the case of a constant supply, from the main water-pipe—the supply pipe being guarded by a ball valve. The pipe from this waste preventer to the closet is guarded by a valve, frequently the conical one known as the spindle valve, which can be raised by means of a lever worked by a chain and ring. When the chain is pulled, the spindle valve is raised, and the two or three gallons contained in the water-waste preventer are discharged into the hopper closet, while at the same time the ball valve is also raised by the lever, so that no water can come into the waste preventer while the chain is being pulled. It will be seen that this and similar contrivances not only prevent direct connection between the water-closet and the drinking water of the cistern or main water pipe, but also prevent an inordinate waste of water. Other water-waste preventers will be mentioned shortly. An improvement on the ordinary hopper closet is the "Artisan" closet, made by Messrs. Beard, Dent, and Hellyer, in which the hopper is provided with a flushing rim, which is far better than the old plan of shooting the water in at one side of the hopper. In the "Vortex" closet, made by the same firm, the syphon is much deeper than in the "Artisan" closet, and the water stands in the basin. A two-inch supply pipe is necessary, the water being discharged by a flushing rim, and also projected into the middle of the basin, as it is clear that a greater force of water is required to flush out so deep a syphon. On the other side of the syphon is placed a ventilating pipe to carry away any foul air.

We now come to various forms of "Wash-out" closets, the first being Jennings's "Monkey" closet. In this, a small amount of water remains in the basin, the opening out of which into the syphon is not at the bottom, as in the case of the hopper closet, but on one side. The advantage of this form of closet is that it is not possible, as is the case with hopper closets, for careless persons to go on using the closet without flushing it with water, as the soil remains in the basin until it is flushed out. Hopper closets, on the other hand, may be used for

a long while without any supply of water at all, and this is the way in which pipes frequently get stopped up. In the monkey closet the basin and syphon are all in one piece of earthenware. In Woodward's "Wash-out" closet the basin is provided with a flushing rim, and the syphon is separate from the basin, so that it can be turned in any direction necessary. In Bostel's "Excelsior" closet the basin and the syphon are in one piece of earthenware, and the outlet at the back of the basin. The water-supply pipe is made to enter the basin by two branches, one on each side, and a flushing rim is provided. At the back of the basin is a vertical opening leading directly into the syphon, by means of which anything improperly thrown into the closet can be removed. An overflow-pipe is also provided, but this is, in most instances, useless. Dodd's "Wash-out" closet is somewhat similar in shape to the others, but has a ventilating pipe attached to the discharge pipe immediately beyond the syphon. An inch and a quarter supply pipe should be used with these closets, and where there is less than six feet fall, $1\frac{1}{2}$-inch pipes may be used with advantage. Fowler's closets are suitable for use in poor neighbourhoods, especially when there is an insufficient supply of water. In this system, rain, sink, and other waste waters are made to wash out the trap of the closet.

The closet apparatus most commonly used in the interior of houses is that known as the "pan" closet, and is a most mischievous contrivance. The basin is conical, and below it is placed a metal pan capable of holding water, into which the lower part of the basin dips. This pan can be moved by the pull-up apparatus of the closet inside a large iron box called the "container," placed under the seat of the closet, and into the top of which the conical basin is fixed. This "container" has a 4-inch outlet at the lower part of it, leading into a trap placed below the floor, the trap being generally a lead "D" trap, from which a 4-inch pipe passes to the soil-pipe, which conveys the refuse from the closets into the sewer. The great fault of the "pan" closet consists in the large iron "container," which is merely a reservoir for foul air, as it always becomes very filthy inside. When the pull-up apparatus is worked, the pan is swung from its position below the basin, and its contents thrown into the "container," the sides of which are splashed with foul matters, and cannot possibly be cleaned. Besides this, the container leads into the D-trap, which always contains foul matters, and gives off foul air into the container. At the same time that the contents of the pan are thrown into the container, foul air from the latter is forced into the house. This can only be partly remedied by providing a ventilating pipe for the container, and carrying it out of doors, but I have more than once seen a ventilating hole drilled into the container, and no pipe attached to it, so that foul air from the container was driven out with a puff that would blow out a candle, each time that the closet was used, and this in closets immediately connected with bedrooms. The D-trap should not be used at all either under closets or sinks. It consists of a lead box shaped like the letter D, placed thus, ⊍. The outlet pipe starts close to the top at one end, and the inlet pipe passes down to an inch or so below the level of the lower part of the outlet. Of course water remains in this trap up to the level of the outlet, so that the inlet pipe dips into it an inch or more. The D-traps are never washed out thoroughly at each use of the closet. A deposit of foul matter takes place in them, and foul air is generated. This gradually corrodes the lead, and eats holes through it at the upper part of the trap. I have here several specimens of D-traps with holes eaten through them by the foul air. Such holes, of course, form a means of escape for the foul air from the sewer into the house. The trap is generally made of sheet lead, and not cast in one piece of lead; but an improved form has been made by Messrs. Gascoyne, which is cast in one piece, and in which the inlet pipe is placed at one end, so that there is no space left between it and the end of the trap, for paper, &c., to accumulate in. Instead of a D-trap, where a lead trap is used, it should be an S-trap or P-trap of 4-inch cast lead. This is flushed out by each use of the closet. A lead tray is usually placed on the floor underneath the closet apparatus, the trap being placed sometimes above and sometimes below it. The object of this tray is to prevent any overflow from the closet soaking into the floor and perhaps through into the ceiling below, causing serious annoyance, and perhaps a great nuisance. This tray is commonly called the "safe" of the closet, but, as generally constructed, any other word in the language would be more applicable to it. It is, of course, provided with a waste pipe, and this waste-pipe is almost invariably carried into the D-trap, when there is one below the safe, but it is not unfrequently carried straight into the soil-pipe, with or without a syphon bend on it. When carried into the D-trap, it is usually made to enter below the surface of the foul water therein contained, but I have not unfrequently seen them carried straight into the top of the trap, and so form a passage for foul air into the house. They ought not to be connected with any part of the water-closet apparatus, trap or soil-pipe, but ought to be carried straight through the wall to end in the open air, being merely provided with a small brass flapper to keep draughts out. The waste, or overflow pipes of cisterns, are frequently carried into the D traps of closets, in which case foul matters get washed into the inside of these pipes, and foul air from them contaminates the water in the cisterns. This is even a greater evil than the last, and the waste pipes of all cisterns, but more especially those used for the supply of drinking water, should, as stated in a previous lecture, be made to end in the open air.

We come now to valve closets, the numerous varieties of which are modifications of the original Bramah's valve closet. In this the aperture at the lowest part of the basin is closed by a water-tight valve, which can be moved in a small valve box, placed immediately below the basin, by means of the pull-up apparatus—the valve box itself being connected below with the trap. Thus, the necessity for the large iron container, so objectionable a part of the pan-closet, is done away with, and its place taken by a small box, in which the valve moves. As, however, the valve is water-tight, provision is made for the overflow of water from the basin, in case the latter should be filled too full, either by slops being thrown into it, or by the water continually running from the supply-pipe in consequence of a leaky valve. The over-

flow pipe starts from one side of the basin in which holes leading into it are perforated. It is then, as a rule, carried downwards into the valve box, having a small syphon bend on it before entering. The water from the supply-pipe, as it enters, is made to flow round the basin by an inner plate, generally made of metal, called the "spreader," or still better, in the improved form of valve-closet by means of a flushing rim. Thus, some of the water at each use of the closet passes through the holes leading into the overflow pipe; the object of this being to keep the syphon on that pipe charged with water, as it is clear that if this syphon is not charged, the overflow pipe ventilates the valve box, that is to say, the space below the valves, and the surface of the water in the trap below into the basin of the closet. Now, as a rule, the syphon trap on the overflow pipe does not remain charged with water, and even if it does, is of little use, for the following reasons — when by the pulling up of the handle the valve is made to move suddenly in the valve box, air from the latter is forced out through the water in the syphon bend of the overflow pipe, as anyone can see, who will take the trouble to place a piece of moist tissue paper over the hole in the side of the basin leading into that pipe, and then work the handle of the closet. Thus foul air from the valve box is driven into the basin, even when the syphon on the overflow pipe is charged. Furthermore, as the mass of water in the basin rushes down through the valve box into the trap it carries the air along with it, and when the valve is closed runs out of the valve box, drawing air through the overflow pipe, and diplacing the water in the syphon, which is in many cases left quite uncharged. Various remedies have been proposed for this. In Bolding's "Simplex" valve closet a small pipe is carried from the water-supply pipe into the overflow just above the syphon, with the view of supplying water direct to the syphon each time the closet is used. In Jennings's valve closets the overflow is trapped by means of a patent india-rubber ball trap, which is something like a Bower trap upside down. It is constructed so that the overflow water can displace the ball from the end of the water-pipe and flow away round it, but any pressure of air from the valve box would only cause the ball to fit more closely against the end of the overflow pipe. In the valve closet made by Beard, Dent, and Hellyer, the overflow pipe is made much larger than usual, and the syphon deeper, so that it holds a larger quantity of water, and at the same time a ventilating pipe is inserted into the valve box, and should be carried through the wall to the outer air. By this means no accumulation of foul air in the valve box can take place, and any air that is drawn into it, while the water is passing through it, comes in through the ventilating pipe instead of through the overflow. It is quite right to ventilate the valve box, but the best way to deal with the overflow pipe is to disconnect it altogether from the valve box, and either carry it through the wall, placing a brass flap on the end of it, or to let it end over the waste pipe of the safe. Indeed, it is hardly necessary to have an overflow pipe at all, as if the basin does get full, all that will happen is that the water will flow over the top of it into the safe and run away. The advantage of this plan is that the existence of a leaky valve is found out immediately, and the disadvantage is that it is liable to wet the end part of the seat and apparatus below it. Lead D-traps are generally placed under these closets, but this should never be allowed. Syphon traps should always be used, for the reasons already mentioned. Some valve closets are made with a galvanised iron syphon trap that is to be placed wholly or partially above the floor, and is provided with a screw cap that can be taken off for the purpose of cleaning; such closets are made by Messrs. Tylor and Sons, and Messrs. Jennings. The latter also make closets, which may be called "plug" closets, the best known variety having the basin and syphon ball trap all in one piece of china. The plug closes the entrance from the basin into the syphon below, and is connected by a rod with the handle, which is vertically over it. By means of an india-rubber flange the plug is made to fit water-tight into the entrance of the syphon, and a body of water is kept in the basin above it, up to the level of the overflow, which is either made through the plug and the rod joining it with the handle, or by a separate trapped channel along side of it. A plug is also made to contain the patent ball trap mentioned above. It will be seen that in these closets, no valve box is necessary, and there is only a small air-space between the water in the trap and that in the basin. These closets are also made without any trap at all, in which case the overflow of the basin is carried, by a pipe, straight through the wall. Such trapless closets are often very useful on the ground floor, where the soil-pipe can be carried straight through the wall, and disconnected from the sewer by a ventilating trap outside.

We must now consider more in detail the arrangements for the supply of water to the basin. The simplest form of water-waste preventer has already been mentioned, but it must be remembered that the commonest plan for supplying closets with water, is to place a spindle valve in the bottom of a cistern somewhere above them, so as to guard the entrance into the pipe leading to the basin of the closet, and to work this valve by means of wires connected with the pull-up apparatus. The great disadvantage of this apparatus is that the wires get stretched by use, and have to be shortened from time to time. There is, obviously, also no provision against waste of water, for the water will run as long as the handle is held, or fastened up, until the cistern is empty. Neither is there any "regulator" to ensure a sufficient supply of water being delivered to the closet each time that the handle is pulled up, whether it is held up or not. I have here one kind of valve which achieves these two objects (lent by Messrs. Tylor and Sons), fixed in a cistern with glass sides, so that you may see its action. When the handle of the closet is worked the valve is raised, and if the handle is let go, the valve does not fall directly but gradually, so as to allow a certain quantity of flow out into the basin of the closet. But if the handle is held up (or down in the case of a ring and chain, as here) a metal weight which was carried up with the valve falls, and stops the flow of water. These valves may be used in cisterns, and connected with the pull-up

apparatus by wires, or they may be placed in the small waste-preventing cistern already described, with view of ensuring the use of a definite quantity of water each time. In another of these waste-preventing cisterns the pipe supplying the closet does not start from the bottom, but starts inside the cistern in the form of a syphon, which is so arranged that when the water is once started it all runs off. Another waste-preventer, of which I have a specimen here, has been recently invented by Mr. Jennings, jun., and consists of a heavy metal cylinder with a piston inside it, the rod of which is the rod to which the handle of the closet is fixed. Upon this cylinder are two projections, one of which lifts the lever which turns on the water, and the other one which moves the valve. The piston is made so large that the cylinder adheres to it, and when the handle is pulled up the cylinder is, therefore, lifted with it, and the valve opened and the water turned on at the same time, but if the handle is held up too long the weight of the cylinder gradually overcomes its adhesion to the piston, and it falls, closing the valve of the closet and turning off the water at the same time. Thus, this water-waste preventer does not come into action at each use of the closet, but only when it is wanted. Not only water-waste preventers, but regulator valves are used in all the best forms of closets. There are, as already hinted, valves that are so constructed that they allow a certain quantity of water to pass through them whether the handle of the closet be held up or not, so that the proper quantity of water is supplied even if the handle is pulled up and let go at once. The oldest and best known of these is Underhay's regulator valve. The valve itself is, of course, worked by a lever, and the rate at which the value is closed depends upon the rate at which the lever falls. This rate is regulated by the fall of a piston in a cylinder, the escape of air from which can be controlled by means of a small tap, so that the rate at which the lever will fall and close the valve, and, therefore, the quantity of water which will pass into the basin each time that the handle is pulled up, can be regulated to a nicety. The commonest form of this regulator is known as the bellows regulator. Other regulator valves are Tylor's and Jennings's, in which, by means of simple arrangements, the rate at which the lever falls and closes the valve can be controlled. When water is delivered on the constant service at high pressure, Common's waste preventer is sometimes used. In this the requisite quantity of water is collected under pressure in an iron cylinder, the air in which is compressed by the pressure of the water from the main. When the handle of the closet is pulled up, it moves a valve, which closes the pipe from the main, and opens that leading into the basin of the closet. The compressed air in the cylinder then expands, forcing the water before it into the closet, and no more water will come in from the main until the handle is put down again, when it can only flow into the cylinder, and not into the closet. Vessels containing disinfectants or deodorants are sometimes attached to closets in such a manner that a certain portion of disinfecting or deodorising fluid is thrown into the water in the basin each time the closet is used; but, if closets are properly constructed, this is not necessary.

We next come to the soil-pipe, which conveys the waste matters from the water-closet to the sewer. Soil-pipes are most frequently made of lead, and they should, as a general rule, be 4 in. in diameter. Formerly, when made of lead, they were necessarily seamed pipes, as drawn lead pipes were then unknown. Consequently, there were not only soldered joints at the ends of the lengths, but a soldered seam longitudinally the whole length of the pipe. These seamed pipes should never now be used, and where found should always be taken out, as the seam gives way sooner or later, even when the pipe is placed quite vertically, and it then allows foul air to escape into the house. Pipes of drawn lead should be used, so that the only joints are at the ends of the lengths, and these can be made, and are commonly made, more durable than the pipe itself, which is not the case with the seamed joints. Iron soil-pipes are sometimes used, and, indeed, are preferred in climates where there are great variations of temperature, as they expand and contract less than lead ones do. But in this climate drawn lead soil-pipes are preferable, especially if they are placed, as they frequently are, inside houses, in which position I should never allow an iron one to be fixed, on account of the difficulty of being sure that air-tight joints are made; and even outside a house leaden ones are to be preferred, although more expensive, because, when iron ones are used, it is usually necessary to put lead pieces in to receive the lead pipe from the closet, to prevent a joint between lead and iron being made inside the house, and however carefully this is done, it always looks like a patched-up job. When lead pipes are placed outside houses, it is, however, necessary to have them cased to protect them from mischief or violence. The small additional expense is of little consequence, and it is better to have them cased throughout their entire length with galvanised iron. In order that they may not project too much, a chasing in the wall can be made sufficiently deep to receive about half the pipe. Stoneware pipes are sometimes also used for soil-pipes, but are not to be recommended inside houses, at any rate, on account of the numerous joints that have to be made. Occasionally, where work is "scamped," soil-pipes are even made of zinc, and I have a specimen here of a D-trap made of very thin lead, with a zinc soil-pipe attached. The latter has been eaten through by the foul air, as might be expected. Foul air is also capable of perforating lead soil-pipes, especially if they are not ventilated, and I have here a specimen of a lead soil-pipe, which was taken from under the floor of a bedroom, where it had very little fall, and which is seen to be perfectly riddled with holes, eaten through the solid lead by the foul air which accumulated in the pipe. In order to ventilate a soil-pipe, it is not sufficient merely to carry a small pipe, such as an inch or even a 2-inch pipe, from the upper part of it to the top of the house, but the 4-inch soil-pipe itself should be continued (full bore) to the top of the house, and should, as a rule, project above the ridge of the roof. It may be covered simply with a perforated conical cap, not fixed on to the top of the soil-pipe, but fixed so as to stand a little above it, and not to obstruct the flow of air out of it, or

two or three copper wires may be fixed across the top, so as to prevent leaves from getting into it. Cowls of any kind are quite unnecessary, at any rate in the great majority of instances. Where an air inlet is made into the house sewer, the soil-pipe should be carried into the latter by means of a bend—no trap of any kind being placed at the foot of it, but where this is not the case, or where it is not proposed to ventilate the house sewer by means of the soil-pipe, or where the soil-pipe cannot be carried above the roof, it is advisable to place a disconnecting trap of some kind at the foot of the soil-pipe outside the house. In any case it is necessary that provision should be made for a free passage of air through the soil-pipe. Where the vertical soil-pipe is at some distance from one or more closets, so that the branch pipes from the closets to the soil-pipe are, perhaps, a few feet long, it is a good plan, and sometimes necessary, to carry small ventilating pipes from below the traps of the closet, and connect them to a pipe outside the house, which should be continued up above the roof. This will prevent an accumulation of foul air in the branch pipes, and will also prevent the water passing down the main soil-pipe from drawing the water out of the traps of closets beneath. It has even been proposed by Mr. Norman Shaw to disconnect the branches of the soil-pipes of the closets from the main soil-pipe outside the house, by making them discharge into open heads, something like the heads of the rain-water pipes; and Dr. Heron has devised a plan in which part of the branch pipe is moveable, and so arranged that it is only connected with the main soil-pipe when the lid of the closet is open, but is removed from it by the closing of the lid; while Mr. Buchan has proposed that the branch pipe should be a channel pipe, freely open to the air along the top.

Water-closets should, whenever it is possible, be separated from the house by a ventilated lobby, or, at any rate, there should be two doors with special mean of ventilation for the space between them, and this leads me to speak of Mr. Saxon Snell's invention, of which I have a full-sized model here, lent by Mr. Howard, the maker. In this, by means of an arrangement called "The Duplex Lid," the closet apparatus is placed, by the closing of the lid, in a shaft which is carried up above the roof of the house. The water supply apparatus is also connected with the lid, so that the lid has to be closed in order to flush the closet.

We come now to sinks and baths.

Of sinks there are various kinds. Sometimes sinks called "slop sinks" are provided to get rid of the dirty water, although where wash-out or hopper closets are used the slops may be thrown down them. The waste-pipes from slop sinks should be provided with syphon traps, and are, as a rule, connected with the soil-pipes. They are, in fact, looked upon in much the same light as water-closets. The other upstairs sinks, as "housemaid's sinks," and the small sinks under taps, known as draw-off sinks, must not be connected with the soil-pipe or water-closet apparatus. Their waste-pipes should always be provided with syphon traps immediately under the sinks, in order to prevent air coming into the house through these pipes, as it is rendered foul by so doing, but at the other end these waste-pipes should always be disconnected from the house sewer by discharging into a pipe with an open head like a rain-water pipe, or over a gully in the area. Scullery sinks should also be disconnected from the sewer, but there is a difference of opinion as to whether or not this should be by means of a trap large enough to collect the fat from the greasy water thrown down there. If such a trap is used, it must contain a sufficient amount of cold water to cool at once the hot water from the sink that is thrown into it. But, in any case, the pipe from the sink should pass under an open grating before entering such trap. The waste-pipes from baths should also be invariably disconnected from the house sewer in the same way as those from sinks. The waste-pipes of baths should be large, say two inches in diameter, not only so that they may be quickly emptied, but that the large body of water being discharged suddenly may be made to flush the house sewer. In large houses, where there are laundries, this is a still more important matter. A bath should have a lead "safe" tray placed under it, the waste-pipe of which must go straight through the wall of the house, and end in the open air. The disconnecting traps used in the areas for the waste-pipes of sinks and baths may be either the ordinary syphon gully-trap with a galvanised iron grating (the waste-pipes being made to discharge either over the grating, or preferably, as a rule, through holes in the sides of the trap below the grating, but above the water in the syphon), or Mansergh's trap may be used, especially for scullery sinks, or sinks on the basement floor.

To conclude. The principles that guide us in carrying out sanitary works are simple enough, but sufficient has been said in these lectures to convince everyone that it is only by the minutest attention to details that we can hope to guard ourselves against the dangers that surround us, especially in the contrivances for the removal of refuse matters.

NATIONAL WATER SUPPLY CONFERENCE.

REMARKS ON SOME OF THE DISEASES DUE TO SEWER-GAS POISONING.

By John Brown, L.R.C.P., London, &c.,

Officer of Health to the Bacup Urban Sanitary Authority.

During the summer and autumn of 1878, I made a large number of observations on the effects of breathing an air contaminated by sewer-gas. I have notes of thirteen houses in which drain diseases existed, and in which there were grave sanitary defects, such as ought to have attracted the notice of the householders. Unfortunately, the public are very careless on these matters, especially the working classes. Happily, there are signs that the more educated are becoming alive to the vital importance of pure air and water. In seven houses the slop-stone pipe was untrapped, and went straight into the drain, and from which there arose bad smells, especially in the summer. In the remaining six there were untrapped and rubble drains (not ventilated) which were close to the door of the house, or passed beneath the floor.

The following are the diseases observed:—

A. *Inflamation of the Lymphatic Glands*, more commonly the cervical. As a rule the glands are not acutely inflamed. Every case was among young children; they are obnoxious to it.

B. *Abscesses.*—In some cases the inflamed glands suppurated. The abscesses are generally chronic and almost painless. These, too, are more common among children. The abscesses may form in any part of the body. The following were observed:—*a.* Submaxillary abscess; *b.* Cervical; *c.* Axillary; *d.* Inguinal; *e.* Facial; *f.* Pelvic; *g.* Multiple abscesses; *h.* Temporal abscess.

C. *Diarrhœa.*—Sewer-gas is probably a fertile source of summer diarrhœa, especially among infants and young children, who live in unsanitary houses. The diarrhœa is very difficult to cure, and often ends fatally. In some cases there are other conditions, such as bad feeding, which tend to keep up the disease.

D. *Sore Throat.*—In one house there were three cases of sore throat in adults, and one child suffering from diphtheria. The child died and the adults recovered. It would appear that the poison which caused diphtheria in the child, caused sore throats in the adults.

E. *Typhoid Fever.*—Though I have included this among drain diseases, yet I would not affirm that it can be generated *de novo* from sewer-gas. In two cases there were probabilities that the germs of typhoid fever may have been latent in the sewers for years. In one case, however, it was impossible to trace the origin, or to suggest the cause, except the sewer-gases.

F. *Puerperal Fever.*—I have observed several cases in unsanitary houses. I believe a parturient woman runs a great risk of septicæmia if delivered in an air contaminated with sewer-gas.

G. *Anæmia.*—This is found more often among children and young persons.

H. *Nausea, Languor, and Headache.*—The symptoms are not uncommon among adults, generally women. These symptoms are so markedly due to bad smells, that the patient will often suggest it as a cause.

All the above diseases may be due to other causes, and it is possible that the detection of foul smells in houses with these diseases may be a coincidence. The following will help us in forming a diagnosis. If two or more persons in a house are suffering from summer diarrhœa, chronic abscesses, enlarged cervical glands, we may suspect sewer-gas poisoning. Medical treatment is often ineffectual until the patient is removed into a healthier atmosphere, when a speedy cure follows. In the winter, when the decomposition of sewage matter is far less active than in the summer, I have found that infantile diarrhœa and chronic abscesses are very few when compared with the number seen in the summer.

Sewer-gas is especially dangerous to young children. Of 25 persons suffering from sewer-gas poisoning, 17 of these were under 16 years of age. Older persons are not so soon affected; in them it often causes anæmia, languor, nausea, and headache. The following gives the diseases found in each house, with ages of the patients, and probable source of the sewer-gases:—

House No. 1. *Submaxillary abscess*, and *enlarged cervical glands*, in children aged two and five years respectively. There were untrapped slop-stone, and bad smells from a rubble drain.

2. *Cervical abscess* in a child, aged nine years, probably due to bad smell from defective drain.

3. *Axillary abscess* and "*summer-diarrhœa.*"—The child, aged five years, also had other enlarged glands in the axilla and elbow. Diarrhœa occurred in a patient aged six weeks. Another child had recovered from a submaxillary abscess. There were bad smells from untrapped slop-stone and defective drains.

4. *Two cases of inguinal abscess* and *summer-diarrhœa.* One of twins died from exhaustion, due to inguinal abscess, and the other from diarrhœa. The mother recovered from *inguinal abscess*, the cause being sewer gas from an untrapped slop-stone pipe.

5. *Facial abscess* in a girl, aged nine years. This was probably due to sewer-gas from an untrapped slop-stone pipe.

6. *Pelvic abscess*, and three cases of "*summer-diarrhœa.*"—A patient had been confined six weeks. She was very anæmic, and had no appetite. This was due, undoubtedly, to the bad smell in the house. She was taken ill with an abscess in the pelvis. Just at the same time there were three other cases of summer diarrhœa in the house. The infant died. For the sake of the woman, I recommended that the family should remove at once, which they did, and the patient made a good recovery. The abscess discharged itself *per vaginam.* The cause was a defective privy, from which there was a continual leakage of fæcal matter into the house.

7. *Multiple abscesses.*—A baby, aged six months, had twenty abscesses, scattered on its legs, arms, and body. This state was due to bad emanations from a defective privy. The privy was at once altered at my suggestion, and the patient speedily recovered.

8. *Temporal abscess* in a patient aged eleven years. The cause was foul emanation from a defective drain.

9. *Typhoid Fever.*—A death from typhoid fever being reported to me, I inspected the house, and found that bad smells came from the untrapped slop-stone pipe.

10. *Typhoid Fever.*—Another death from typhoid fever was reported. On inspection, I found the slop-stone untrapped, and an untrapped drain close to the door.

11. *Typhoid Fever.*—This was a case of typhoid fever in a gentleman living in a new, well-built house. On inspection, I found the drains and slop-stone trapped. The wife, however, complained of bad smells coming from the water-closet, which was on the first-floor. The water-supply in the summer being limited, the drain would not be well flushed. The mephitic gases, generated in large quantities in hot weather, would soon saturate the water in the pan of the water-closet, and pass into the house. The drain was long and unventilated; and the sewer-gases, being of lighter specific gravity than the air, would seek an outlet at the highest elevation, which would be the water-closets. The drain has since been ventilated. The patient died.

12. *Diphtheria*, and three cases of *Sore Throat.*—A child, aged three years, had diphtheria, and died in three days. In the same house, there were three adults suffering from sore throats, all of whom recovered. I found that there was a bad smell from untrapped slop-stone.

13. *Puerperal Septicæmia.*—The third day after confinement, the patient had usual symptoms of septicæmia. She nearly succumbed two or three times. After about five weeks, she had a relapse, which proved fatal. In this case there was a foul smell from an untrapped drain, within a few feet of the door where the patient was confined.

THE RECENT OUTBREAK OF ENTERIC FEVER AT CATERHAM AND REDHILL.

By R. Thorne Thorne, M.B. Lond.; F.R.C.P.

At the request of the Society, I herewith submit a brief account of the circumstances under which an extensive epidemic of enteric fever has recently arisen, in and near the towns of Caterham and Redhill. Having already prepared a detailed report as to all the circumstances of the epidemic, and this report having been publicly issued by the Local Government Board, I propose here to confine myself to such a *résumé* of the facts ascertained, as may serve to form the basis of a discussion, which I am informed the Society desires to entertain on the present occasion.

During the fortnight ending February 2nd last, enteric fever broke out at Caterham, Redhill, Earlswood, Bletchingley, and Nutfield, in the county of Surrey. The outbreak appeared almost simultaneously in Caterham and Redhill, the attacks commencing in the one town only a few hours after they were heard of in the other; and within a few days cases also came under treatment in the other places named, the total number of attacks reaching 196 during the fortnight referred to. Here were a series of outbreaks almost simultaneous in their incidence upon a series of towns and villages, which were situated at distances varying from about three to ten miles apart, and which were all ascertained to have been, for a long time, remarkably free from the disease by which they were now attacked. And in view of the facts ascertained during the early stages of the inquiry instituted, there appeared the strongest grounds for concluding that the several outbreaks in the several localities constituted one epidemic, and that they had one common origin. The period of incubation in enteric fever being about, or somewhat under, a fortnight, these 196 cases could be made the subject of inquiry, with regard to causation, apart from any source of error which might be due to the spread of infection by means of any of the earlier attacks in the same epidemic.

All the sanitary circumstances of the populations affected were minutely investigated, the inquiry in this respect including, though being by no means limited to, all the conditions which previous experience had shown to be related to the prevalence of this disease. The various systems of sewerage and drainage, the several means of excrement and refuse disposal, and the numerous milk services, were in turn dealt with; but not only could nothing be ascertained with regard to them which had any bearing upon the epidemic, but none of the affected localities had anything in common with respect to any one of these conditions.

There was, however, one condition which the several towns and villages where the disease prevailed had in common; they all derived their water-supply from the same source, namely, from the works of the Caterham Waterworks Company. And not only so, but it was ascertained that among the occupants of over 1,400 houses, within the infected district, to which the Company's supply was not delivered, no persons who had not consumed this water were affected, and also that from amongst those who habitually used other supplies, the disease had specially attacked the few who had been recent and occasional partakers of that derived from the Company's mains. The suspicion, however, which under these circumstances naturally attached to this water, received no support either from consideration of the source whence it was derived, namely, the chalk wells, more than 500 feet deep, sunk at the southern extremity of the high-lying ground which bounds the Caterham Valley on the west, nor from the history which had attached to its previous use, and which, in point of wholesomeness, had won for it a deservedly high reputation. But the evidence which associated the spread of the epidemic with the consumption of this water gradually became overwhelming, and hence everything relating to its sources, storage, and distribution was, with the ready co-operation of the Company's officers, carefully inquired into.

The possibility of soakage of filth into either of the wells from cesspools, had, even prior to the occurrence of the epidemic, attracted some attention. But, although the steadily increasing practice of fouling the chalk, in various parts of the Caterham Valley, by means of cesspool soakage, is one which can hardly fail, before long, to constitute a source of danger to the water services deriving their supply in this locality from this stratum, if indeed it does not do so already; yet it appeared obvious that the epidemic in question had not been brought about in this manner.

Amongst the many other points investigated, was the possible occurrence of any contamination of the water in the mains, owing to the suction of foul air or other matters into them, during periods of intermission. But no such intermissions had occurred.

Circumstances had, however, in the meantime come to my notice, which led to the inquiry as to the cause of the contamination of this water-supply being extended in another direction.

During the latter part of 1878, and the beginning of the present year, the Caterham Waterworks Company constructed an adit from one of their old wells up to a new bore, which had been made for them by the Diamond Rock Boring Company, and which was at the time approaching completion. This adit is situated in the chalk at a depth of 455 feet. It measures 6 feet by 4 feet, and is 90 feet in length. A number of men were employed in this work, some of them being in the well below, others on the surface. Inquiry was made as to whether any of the men had ailed whilst at work, and it was ascertained that one of them, who left work some time in January, was believed to have been ill, although no inquiries had been made concerning him since he quitted the works. This man was found out, and the history obtained, both from him and from his wife, can leave no doubt but that he had recently suffered from enteric fever. Indeed, it was ascertained that, though continuing at his work in the adit below, he was, from about January 5th until January 20th, when the severity of his symptoms confined him to his bed, the subject of a mild though marked attack of enteric fever, which was accompanied with such profuse diarrhœa that, notwithstanding certain regulations to the contrary, he was compelled to evacuate in the adit "at least two or three

times" during each shift. The exact method by which his poisonous evacuations found their way into the water is a little uncertain, but even assuming the absolute truthfulness of his statement to the effect that a pail, which was constantly being drawn to the surface, was invariably resorted to as a closet, there were ample means, on his own showing, by which the well-water could have been contaminated by them. Within 14 days of the commencement of his purging, the disease broke out in an epidemic form, amongst the consumers of the Company's water.

Confirmatory evidence as to the nature of the man's illness was obtained, when it was ascertained that on the previous December 25th, 26th—the exact date when his disease, if enteric fever, must have been contracted—he had been away from Caterham, and had stayed in a town where that disease had been somewhat prevalent.

In short there can be no doubt that the pollution of this water, as the result of the man's disease, and the epidemic in question, were related to each other as cause and effect; indeed the several essential incidents recorded are linked together in point of date, with a precision characteristic of the results which might have been expected to have followed a scientific inoculation.

One additional circumstance bearing upon the correctness of the view I have expressed, may be noted. The village of Warlingham, where the Caterham Company's water is laid on to as many as 156 houses, exhibited an immunity from the epidemic. But at the precise period when the Caterham water must have been most potent for harm, some 12,000 gallons a day of an altogether different water was, owing to a temporary emergency, pumped into the main that supplied that village.

As soon as the main facts of the epidemic had been ascertained, the inhabitants of the affected district were, by public notice, cautioned against the use of the Caterham water, and steps, including the copious use of disinfectants and long continued pumping to waste, were taken by the Company to get rid of all possible contamination. The efforts in this direction appear to have been thoroughly successful, for the epidemic soon ceased, and it has not been renewed, although the water has again been brought into general use. The total number of cases, however, which were reported to me at the time, and which have since been heard of, cannot fall short of 370. By far the majority of attacks were of an unusually mild type, and the fatal cases were limited to 21.

Amongst the points deserving special notice in connexion with the circumstances of this epidemic, I would suggest the following:—

1. That the view, to the effect that even a comparatively minute quantity of the poison contained in the evacuations of enteric fever patients may, when subjected to conditions favourable to the development of that poison, lead to the specific infection of very large volumes of water to which it has gained access, is fully borne out.

2. That a special danger attaches to the prevalence of the mild—or, as they have been termed, "perambulatory"—cases of enteric fever, by reason of the intensely poisonous nature of the diarrhœa which characterises that disease.

And having regard to these facts:—

3. That all possible sources of excremental contamination, in the vicinity of water-sources, should be rigidly dealt with

4. That care should be taken, in connexion with works for the construction or storage of water, to exclude from employment all persons suffering from any diarrhœal affection.

MEMORANDUM OF RECENT EPIDEMICS PRODUCED BY POLLUTED WATER SUPPLY.

By Ernest Hart.

(Chairman of Council of the National Health Society.)

The accompanying summary contains the facts as to the causation, progress, and fatality of epidemics of a certain class of zymotic disease, in England, which have been proved by official investigation to have been due to polluted water, since the passing of the Sanitary Act, 1866.

The summary has been limited to cases which have been investigated by the Medical Inspectors of the Privy Council and of the Local Government Board, (1) because it is believed that all, or nearly all, the considerable epidemics caused by bad water since 1866 have been investigated on behalf of the Government, and (2) because it is only in these official reports that the facts as to causation, progress, and dimensions of epidemics are fully and accurately stated. An examination of some hundreds of outbreaks unofficially reported during the last twelve years, says that for the most part they have not been investigated with the required accuracy.

The summary, which has been compiled with considerable labour, refers, it will be observed, to epidemics of enteric fever only. Cases have arisen in which outbreaks of scarlatina and diphtheria appear to have been connected with impure water; but as this connection is merely hypothetical, it has been judged best to omit any reference to the outbreaks in question.

It need hardly be stated that the chief causes of the spread of enteric fevers are excremental pollution of the air or water, or of both. In epidemics occurring in towns which have a common water supply, the influence of the water in the propagation of the disease can be accurately measured. But where, as is too often the case, enteric fever breaks out in a place whose only water supply is from private wells, and whose only system of excrement disposal is by means of privies, it usually becomes quite impossible to say how much of the epidemic is due to the polluted water, and how much to the fouling of the air from infected privies. Doubtless, soakage from the privies into the wells is mainly the cause of the spread of the disease; but investigators have, in the vast majority of cases of this sort, been baffled in assigning the precise cause of the outbreak, because every condition favouring its origin and spread existed in abundance at the place.

In the admirable series of Reports on the Public Health, published under the direction of Mr. Simon, instances of outbreaks of this kind are to be found by the hundred. Such of these as have produced the most definite results as regards water, are

recorded in the summary; but it must be remembered that there are very many more in which water, though it played an important part, was not alone concerned in the propagation of the epidemic.

It is impossible to make any sort of estimate of the number of lives annually sacrificed in this country at the shrine of polluted water. But the deaths must represent a very considerable proportion of the fatality from enteric fever, to say nothing of other diseases. When it is remembered that, in 1877, no less than 6,879 entirely preventable deaths occurred in England and Wales from this one disease alone, and that thus, in one year, some seventy thousand people were caused needless suffering and anguish, through the ravages of a disease intimately connected with filth, it will be seen how great a stake England has in the maintenance of the purity of its water.

The doctrine that a vast influence is exercised over the health of communities by the quality of water which they consume, is one, says Mr. Simon, "which, as far back in literature as any reference to such questions could be expected to exist, may be seen to have universal medical consent in its favour. During long ages of history, the common instincts of mankind were even surer and stronger than undeveloped science could be, in revolting against the use of unwholesome waters. For instance, among the lessons which survive in modern times from the wonderful intellect and vigour of ancient Rome, the frequent far-reaching aqueducts, which record an unbounded care for the provision of proper urban water supplies, are monuments kindred in spirit, and only second in dignity, to the consummate system of jurisprudence of the same singularly organising people." Of the many invaluable additions and improvements which medical knowledge has received during the last thirty or forty years, scarcely any can be compared for present practical importance to the discoveries which have given scientific exactitude to parts of the doctrine so ably referred to by Mr. Simon. The connection between impure water and diseases, although amply proved, does not rest on so exact an experimental basis as could be desired, probably on account of the imperfections of our present modes of analysis of water. Moreover, the evidences of this connection differ very much with regard to different diseases, both as to the amount and value of evidence. There are some people who deny that even considerable organic or mineral impurity can be proved to produce any bad effect; whilst others have believed that some mineral ingredients, such as calcium carbonate, are useful. On these points I cannot now dwell, and I must, therefore pass over any examination of the diseases, such as diarrhœa, goitre, malarious fevers, and dyspepsia, which may be induced by water, impure at its source, or highly charged with mineral or other impurities. I proceed at once to consider the dangers—and they are immense—of

(*b.*) *Water Polluted with the Specific Infection of some Particular Disease.*—Two diseases, closely correlated, stand out in very bold relief in this connexion. I refer, of course, to cholera and typhoid fever. It is to be hoped that the system of medical inspection, now in force at all our ports, will suffice for the future to nip in the bud any stray cases of the former disease that may reach our shores. In the epidemics which occurred from cholera in this country in 1849, 1854, and 1866, its spread, by means of water polluted with its specific infection, was painfully and convincingly proved by a greater mass of evidence than had ever been previously collected. With regard to any other disease, I do not propose on this occasion to attempt to give any illustrations of the spread of cholera by water. The Broad-street pump outbreak, investigated by Dr. Snow, to whom we owe the first proofs of the spread of cholera by water, is historical. There are many other instances recorded on pages 153 to 161 of the Sixth Report of the Rivers Pollution Commission, but as the time is short, and cholera is an exotic disease which we have only occasionally to fear, I hurry on to an examination of the spread of typhoid fever by water. Here there is of evidence an overwhelming *embarras de richesses.* Epidemics by the score, nay by the hundred, might be cited in which the first cause has been the pollution of the water drank by the persons affected. In fact, it has been one of our most familiar experiences, one which will be found exemplified in every volume of every medical journal, that excremental fouling of wells is, in this respect, among the worst dangers which can threaten the health of a community; and other common water supplies, as distributed by companies and local Boards, are equally capable of spreading the infection. In the admirable Fifth Report of Mr. Simon, an abstract is given of the history of no less than 146 epidemics of typhoid fever investigated by his department during the four years 1870-3. In all these cases great excremental pollution of air or water—generally of both—was found. Since then several very remarkable outbreaks of the same kind have been investigated by the Local Government Board with the same result.

These reports may be broadly divided into three sections, those showing the impurity to be imparted (1.) at the source; (2.) in transit from the source to the reservoirs; (3.) when stored in tanks or cisterns. It will be obvious that the two last dangers concern town water only, *i.e.*, that delivered in pipes to the several houses. The first mentioned source of impurity is, therefore, the one which we most commonly find as concerned in rural districts with the spread of typhoid fever. In country places wells are not uncommonly found in close juxtaposition with privies, and soakage from the latter to the former inevitably ensues. The water may perhaps be drunk for a long time without any grave danger to health, but as soon as the infection of typhoid fever gets into the well most serious results follow. Thus, at Hawkesbury Upten, which is situated upon fissured oolite, the sewage is discharged into the fissures, Into the same fissured rock are sunk the wells, and when a case of enteric fever occurred at the top of the village the disease spread through the whole village through the medium of the privies and wells. The use of brook water again, when infected with the contagium of enteric fever, has been proved in innumerable instances to have been the cause of epidemics of the disease. Perhaps one of the most convincing cases of this sort occurred at the orphan asylum founded at Bristol by the philanthropic Mr. Müller.*

* *Sanitary Record*, vol. iii., p. 95.

EPIDEMICS PRODUCED BY POLLUTED WATER SUPPLY.

Place and Reporter.	Date of Epidemic.	Exciting Cause of Outbreak.	Circumstances of the Epidemic.	No. of Cases.	No. of Deaths.
1. Baldock (Herts). Population, 2,000. Dr. Thorne Thorne.	1873-4. Sept.—April.	Water supply from wells in chalk, obviously polluted by cesspools. Outbreak of enteric fever occurred, when considerable disturbance of the polluted strata through which water supplying wells flows, was occasioned by construction of new sewers.	Spread of disease favoured by numerous accumulations of house refuse and over-crowding.	60	3
2. Bedale (North Riding). Population, 1,000. Mr. W. H. Power.	1877. July & Aug.	Case of enteric fever introduced into house when all the conditions for its spread—polluted water, bad drainage, bad excrement disposal, and nuisances—existed.	Precise channel of infection doubtful, but 15 out of 20 families invaded obtained their water from a well to the trough of the pump of which all kinds of foul matters (*e.g.* tools and barrows used in emptying of privies), were brought for washing.	36	5
3. Bourton-on-the-Water (Gloucester). Population, 1,109. Dr. Ballard.	1874. June—Oct.	Evacuations of a typhoid patient cast into a privy which overhangs a stream which supplies many of the villagers with water. Wells commonly in dangerous proximity to privies and drains.	First cases occurred amongst persons drinking the water from the brook. Subsequently epidemic spread throughout the village, because of pollution of local wells by experimental matters from cesspits, containing the evacuations of persons who had suffered from fever, and also by soakage from drains and from brook.	137	4
4. Bradford (Wilts). Population, 7,000. Dr. Thorne Thorne.	1877. April—July.	Water supply of town derived from springs cropping out of the Oolite, the water being procured from wells or reservoirs constructed in the rock. Through fissures in rock the liquid filth of place has long penetrated, till all the supplies of water must be more or less fouled. A case of enteric fever at the "Chantry," under the foundations of which springs flowed, which must have received pollution by soakage from an old stone sewer.	Springs flowing under "Chantry" supplied two houses and a public tap, frequently resorted to by children from a neighbouring school. Twenty children residing in different parts of the town, but attending this school, were attacked by typhoid fever, other cases amongst persons using the tap, and at the private houses to which water was supplied. Closing of tap followed by cessation of epidemic amongst school children. In other parts of town disturbance of soil for sewerage purposes helped on the epidemic.	50—60	8
5. Caius College, Cambridge. Dr. Buchanan.	1873. Nov. & Dec.	Contamination of a particular section of the college water service (by the entrance into it of air charged with the contagium of enteric fever) during a period of intermission.	The epidemic was mainly confined to a particular court, in which it affected all the levels and staircases. It began a fortnight after the intermission of supply. Water-closet air shown to have had direct communication with the water-pipes.	15	[?]
6. Dewsbury, Batley, Heckmondwick, & Ravensthorpe (York). Dr. Thorne Thorne.	1877. Jan.—April.	Believed to be the pollution of the (joint) water supply of these towns at the gathering-ground prior to its delivery to reservoir. One of the streams feeding the reservoirs found to receive drainage of farm-house, stables, cow-house, &c. Suspicious surroundings moreover of conduit from gathering-ground to reservoir. [No other explanation possible.]	Inquiry made too long after epidemic to make the fact of specific pollution of water sure. But enteric fever appears to have attacked at first only people using the water. Epidemic subsequently spread by intermittent water service, allowing suction of tainted air into mains, and by the defective conditions of sewerage and drainage by excrement disposal in the district. Epidemic commenced in each of the districts at the same time, though each had a separate delivery main.	Circa 600	65
7. Guildford (Surrey). Dr. Buchanan.	1867. September.	Houses in a certain part of the town exceptionally supplied on a particular day with water from a high-standing reservoir previously filled from a new well. This well sunk through a porous stratum of chalk, and in close proximity to various sewers, one of which was found to leak in several places.	Epidemic almost exclusively confined to the part of the town corresponding with the particular section of the water supply. People of all classes infected.	264	21

8. Gunnislake (Cornwall). Dr. T. H. Bloxall.	1875. Sept.—Nov.	Evacuations from a man coming into the district with typhoid fever thrown on a dirt-heap, near to an adit feeding a reservoir which supplied the town. Porous soil, steep gradient, and heavy rainfall, doubtless caused specific infection to be communicated to water in adit.	Outbreak confined to area supplied with water from reservoirs. Of 1,916 partaking of water, 138 were attacked. Of 1,085 supplied from other sources, 5 only attacked.	143	6
9. Hawkesbury, Upton (Gloucester). Dr. Ballard.	1872. Feb.—Aug.	Village stands on fissured Oolite, into the fissures of which are discharged the excremental matters of privies, so that privies very rarely require emptying. Into the same rock are sunk the wells, which have been for a long time polluted by the cesspools.	A case of enteric fever, introduced at the top of the village, spread through it by the medium of the privies and wells. It went right down the village to the end.	113	14
10. Hucknall Torkard (Notts.) Dr. Harries.	1872. July & Aug.	Immense rainfall flooded privies and middens, and washed their contents into the wells and streams affording the water supply of the population.	Epidemic spread by impure air, damp houses, &c.	100	10
11. Lewes (Surrey). Dr. Thorne Thorne.	1874. July—Dec.	Pollution of a stream occasionally used for the water supply of Lewes by the river into which the town sewage is poured.	The epidemic commenced at an interval corresponding to the incubation period of enteric fever from the date when the water from the stream was used. It was subsequently spread by the suction of infected air into the mains from water-closets during periods of intermission.	486	37
12. Lower Gornal (Staffordshire). Dr. Ballard.	1873. Aug.—Dec.	No drainage; well water very bad; many persons resorted to springs polluted by sewage from privies.	Epidemic spread through the medium of infected privies, but the principal agents were waters of wells and of the "springs" polluted with infection of enteric fever.	700 (Estm.)	34
13. Nunney (Somerset). Dr. Ballard.	1872. July—Oct.	Brook water used by villages for drinking purposes. The evacuations from an imported case of enteric fever found their way into the brook.	Epidemic attacked water drinkers more especially. When unpolluted water was brought into the village in carts, epidemic ceased.	76	[?]
14. Over Darwen (Lancashire). Dr. Stevens.	1874. Oct.—Dec.	Pollution of water conduit (supplying Darwen) with enteric fever poison, from drain which ran over conduit, and which, imperfect itself, allowed filtration into conduit through the imperfectly secured points of joints.	Epidemic was sudden, and well nigh universal, affecting people living in all parts of the town, and variously circumstanced as the local filth conditions.	2,035	104
15. Redhill & Caterham (Surrey). Dr. Thorne Thorne.	1879. Jan. & Feb.	Pollution of the deep wells of the Caterham Water Company with the specific infection of enteric fever, imparted to it by the evacuations of a workman suffering from that disease, who was engaged in one of the adits of the wells.	Epidemic attacked exclusively (except a few secondary cases at end) persons using the water. Populations with other supplies entirely escaped. Man was engaged in well from Jan. 5—20, and after a fortnight's interval, the attacks commenced to occur; after man ceased work, attacks began to die away.	352	21
16. Sherborne (Dorset). Dr. Bloxall.	1873 Jan.—May.	Pollution of water supplied by local authority with infected air sucked into pipes from closet pans during intermission of supply.	Epidemic attacked almost exclusively persons drinking town water.	243	13
17. Terling (Essex). Population, 900. Dr. Thorne.	1867—8 Dec. & Jan.	Water supply derived from shallow wells, round which every possible pollution had accumulated. A sudden great rise in the water levels after heavy frost and snow, undoubtedly showed that the wells had become the receptacles for the washings of the filth sodden soil.	The whole village became infected, and quite a panic ensued. Children and women suffered most. [The whole village was in a most degraded and unwholesome condition.]	300	41
18. Tideswell (Derby). Population, 1,905.	1876. Mch.—May.	Suction of infected air from closets into main of water service, which was occasionally intermittent.	Of the 16 cases, 10, including all the earlier ones, took water from this main. The pollution of the air from the communication of sink-stone-pipes with an arched-in sewer, doubtless contributed to the epidemic.	16	7
19. Wicken Benant (Essex). Dr. Buchanan.	1869. July—Dec.	Pollution of the parish well with typhoid germs by percolation from brook, into which infected fæces had found their way.	Epidemic almost exclusively ($\frac{42}{45}$) attacked persons using the parish well, or, occasionally, the brook.	45	4

An extensive outbreak (something like 500 cases occurred) was shown by Mr. Davies, the Medical Officer of Health for the city, to have been caused by the drinking, by the children, whilst out for a walk, of water from a stream in a picturesque dingle, but polluted by sewage from a neighbouring village, in which enteric fever was prevalent.*

A very remarkable outbreak, of a totally different kind, has only just occurred near London, in the Caterham Valley. The water supplied by the local water company is above suspicion as regards contamination from cesspools; but some time in January, a man who was suffering from a mild attack of typhoid fever was employed in some work beneath the surface in connection with one of the company's wells sunk in the chalk. There is no doubt whatever that he imparted the specific contamination of typhoid to the water in the well, for, after the usual period of the incubation of the disease, more than 300 cases broke out amongst persons using the company's water. Unhappily, several deaths have resulted from this distressing occurrence, but the company have taken every precaution to prevent a similar accident occurring in future.†

Of the second sort of contamination—that received in the transist of the water from the source to the reservoir—no better example could be given than the epidemic at Over Darwen in 1874.‡ This outbreak, which was minutely investigated by Dr. Stevens, of the Local Government Board, and which attacked 1,500 persons, killing 85, was shown to have been occasioned in the following way. In September, a young lady died of enteric fever, at a house situated close by the "sough," by which the water supplying Over Darwin is conveyed into the service reservoir. Examination showed that a drain carrying away the sewage from the house, passed near this "sough," and had gained access to its interior through faults in its imperfectly secured joints. There was no sort of doubt that this was the true explanation of the epidemic.

Town water, though it is usually absolved from gross impurities at its source as rural water is, has many dangers of its own. In fact, the chance of substances getting into the water of tanks and cisterns is very great. Leakages from ditches, passage of foul air through pipes, or direct absorption of air by an uncovered surface of water introduce impurities into cisterns. A danger which seems capable of wide operation has been seen to arise when water-closets receive their flushing service from the mains of a so-called "constant" supply. This danger is that during times of intermission, if there are not service boxes or cisterns between the closet-taps and the mains, effluvia and even in some cases fluid filth will be (so to speak) sucked into water-pipes. It is to Dr. Bloxall that we owe the discovery of the connexion of this condition with outbreaks of enteric fever. Subsequent investigations by Dr. Buchanan at Caius College, Cambridge, and on a much larger scale at Croydon, in the year 1875, fully confirm this theory. Dr. Thorne has also reported an outbreaks at Lewes and Tidewell, which lead to the same conclusion.

* *Sanitary Record*, vol. iii., p. 85.
† *Ibid.*, vol. x.
‡ *Ibid.*, vol. ii.

MISCELLANEOUS.

THE CULTIVATION OF ECONOMIC PLANTS IN SOUTH AUSTRALIA.

From Dr. Schomburgk's report on the progress and condition of the botanic garden and Government plantations at Adelaide, South Australia, a good idea of the capabilities of the colony for the cultivation of various plants of economic value may be obtained. The introduction into different parts of the world of plants producing fodder for cattle has occupied much attention of late, not only in this country for the purpose of cultivation in India and the colonies, but also, it appears, in Australia. Fodder plants generally, whether grasses or otherwise, have been tried in experimental grounds in South Australia, and though the last summer was the hottest and driest that had been known in the colony for some time, it is satisfactory to learn that several kinds withstood the effects of the drought. Chief amongst these was *Panicum spectabile.* During the hottest time the plants grew vigorously, and not a blade was injured by the heat and drought. Dr. Schomburgk thinks it cannot be too highly recommended, not alone as the best summer grass, but also as a protection against the spread of fire by sowing a strip 12 or 16 feet broad around wheat crops, and as this grass is in its finest condition when the wheat ripens, it would check any fire coming from outward, and after the wheat is reaped there remains a splendid crop of food for cattle and sheep. As it grows only in summer, it is valuable for hot and dry climates. This grass is said to be more easily propagated from roots than from seed, as every little bit grows readily, and produces in the first year plants fit for use, and as it extends rapidly, and by vigorous growth, it is difficult to get rid of it out of the ground. The cocksfoot grass (*Dactylis glomerata*) is also a valuable fodder grass, very productive in consequence of the rapidity with which its leaves grow after being eaten or cut, and possessing considerable nutritive qualities for fattening purposes, is well worth a place amongst cultivated grasses. Of the crested dog's tail (*Cynosurus cristatus*), Dr. Schomburgk says:—"All the domesticated animals, particularly sheep, are fond of the root-leaves, which are produced in abundance. From its forming a close leaf, and having fine foliage, it may be sown on lawns; the drought has no effect upon it." The hard fescue grass (*Festuca duriuscula*) is classed as one of the best grasses introduced into Australia. It seems to thrive in a variety of soils, and from the fineness and bright green colour of its foliage, in summer, is strongly recommended for extended cultivation. Cattle are extremely fond of it, and it endures well the summer heat. Of broom grasses, *Bromus inermis* and *B. longifolius* are both rich and extremely nutritious, ranking amongst the best of introduced grasses. The bastard millet grass (*Paspalum dilatatum*), although a native of Brazil, keeps green throughout the year and affords a fine food crop. *Saccharum cylindricum* is also strongly recommended for its nutritious qualities, and its capabilities of enduring extreme drought. *Pennisetum fimbriatum* and *P. longifolium* both prove to be excellent grasses in dry lands, producing good pasture and good hay, and consequently of high value as fodder plants. *Panicum tomentosum*, although a native of the tropics, appears to endure the drought and heat of South Australia. All the *Panicums* contain nutritive qualities for fattening purposes. Of the well-known tufted hair grass (*Aira caespitosa*) Dr. Schomburgk says of it: "Although a rather coarse grass, forming large

tufts, it stands our drought uncommonly well; not the slightest effect of the heat and dryness is observable on this grass, and no doubt cattle will become used to it." All the above kinds withstood the effects of the unusually dry summer in Adelaide remarkably well, so that they are considered well adapted for extensive cultivation in the colony. Dr. Schomburgk further says:—"I have given my opinion and advice in former reports, and again mention that it is impossible to stock runs with artificial grasses, on account of the large extent of pastoral land, and of the insuperable difficulty arising from climate and drought, to which some parts of the colony, especially the north, are often subjected, so that the squatter must depend on native grasses for his stock, and the only resource for him is to encourage the growth of these. I fear my advice will never be heeded, but the result from wanton destruction of grasses from constant grazing will soon be shown by their disappearance, which must follow. By the practice of grazing the same land throughout the year, and overstocking, the grasses, especially annuals and other herbs, are prevented from insuring their reproduction from seed, and as the sheep crop very closely, even the perennial herbs must succumb."

Most of the better kinds of native Australian grasses have no tendency to form a close turf, and as they mostly grow in tussocks, are more easily eaten out of the ground and destroyed. It is apparent that the stockholder must depend on the native grasses, and it is therefore to his advantage to encourage their growth. To carry this out the runs should be divided up; annually one of these divisions should not be grazed to allow of replacing the pasturage. The grasses should grow unmolested—flower, ripen, and scatter their seeds, so as to ensure their reproduction. Such a system of rotation would improve the growth of pasture. By the present system of grazing the runs constantly throughout the year, much injury is done to the native herbage, whilst every encouragement is given to the growth of noxious weeds, which the sheep will not touch, except when pressed by great hunger, and so these obnoxious herbs will gradually increase, and the better verdure must more and more give way every year, the grasses dying out one kind after another, several species it is said having been quite lost; and the increase of noxious weeds seems to be proved by the fact that, during the last few years, larger numbers of sheep have been poisoned than formerly. Not only has the fertility of the land been exhausted from inattention to the warnings of science, but diseases—*take-all* and *red rust*—climatical disasters, such as drought and frost, become more prevalent. It is also true that the task of introducing any new economic plant, and with it probably a new industry, is not an easy one. We may know all about the structure of such a plant, its life, its distribution and its culture, but for our particular purpose we must also know its natural enemies, besides which there is the important question, will the cultivation of such a plant pay commercially, when we have to compete against other countries where wages range lower; and, again, how long will it be before we can derive a profit from its culture. It is no wonder that many shrink from the experiment rather than wait for the lapse of years before a profit can be returned. The farmer is too much used to the growing of cereals which, no doubt, gives the quickest returns, and, till now, has retarded the cultivation of such plants as require a longer time before a profit can be obtained.

The new fodder plant, known as the "Teosinte"—*Euchlæna* (*Reana*) *luxurians*—a native of South America, has been introduced into South Australia amongst most of our other colonial possessions. As its specific name indicates, it is very luxuriant in growth, enormously prolific, easily propagated, and its stems are very tender, and much relished by cattle, possessing great fattening properties. Though it is only quite recently that the *Euchlæna* has attracted so much attention, its value as a fodder plant has been known for some time. In 1872, M. Darien de Maisanneuve wrote as follows:—"It is a very large gramineous perennial, and very rich fodder plant," for which purpose he considers it has no rival. Each of the plants in the Bordeaux-gardens threw out about 100 shoots three metres long. The tender stems contain a large quantity of saccharine matter, and it is estimated that each plant would supply food for two head of cattle for 24 hours. Reporting on this plant in 1873, M. Rossignan says that in Guatemala it grew in a temperate zone better than in very warm climates. It has been found that it grows most luxuriantly in new moist soil. Cattle fed on it fattened rapidly. The plant is easily propagated by cuttings. In Mauritius, where it has been introduced, splendid results have already been attained from its cultivation. A few seeds sown in dry soil produced enough fodder for two horses a day. The plant can be cut down, and is speedily replaced by young shoots. In New Caledonia, the *Euchlæna* is strongly recommended as a luxuriantly growing plant, and its qualifications as a fodder plant described in terms of the highest praise.

Dr. Schomburgk's experience of this plant in Adelaide is given in the following words:—"I received the seed in July last, and sowed it at once in boxes; it soon germinated, and the young plants showed at once a luxuriant development. As I feared, the season was not far advanced enough to trust them to the open ground, they were planted in 4-inch pots, and kept in a sheltered place until the middle of September, when about a hundred were planted in the experimental ground of the park, the soil being tolerably good, having only been dug. The cold weather checked their growth in the commencement, but, when the warm weather set in in October, their development has been surprising. Notwithstanding that, after planting, they have never been watered, and considering the great dryness of the season, their growth is vigorous. The characteristic of the *Reana*, in throwing out such a number of stems, is also predominant on our plants. The plants do not, as yet (end of February of present year), show the slightest effect from the injurious drought, the leaves preserving their healthy green, while the blades of all the other kinds have suffered materially, and are burnt. It seems that the *Reana* requires the same cultivation as maize and sorghum. The seed should not be planted before September. Due regard being paid to its enormous development, they should be planted at least four feet apart. It would be premature to predict as yet that the *Reana* is adapted to our (Australian) climate so as to become a profitable summer fodder. There is also another important point, viz., will the plant produce seed, and will it ripen with us although the plant is a perennial and will last for years. I am in hopes that the plant will turn out a great acquisition to our summer fodder plants. The plant is liable to be mistaken for maize or sorghum, which it closely resembles, and to which it is closely allied, and, like maize, it bears male flowers at the extremity of the stems, whilst the female flowers appear on the stems."

Of the much advertised prickly comfrey (*Symphytum asperrimum*), Dr. Schomburgk gives it as his opinion that, at least to the South Australian plains, the plant is of little or no use. It has been planted in different soils and situations, and suffered much from the drought. The heat and dryness of the country seem to be too much for it. During the winter months, however, the plants made very satisfactory growth, and produced some fine leaves, but in the month of October the leaves began already to suffer, showing the effect of the warm weather, and dried up before any of the grasses, giving not the slightest promise of being capable of producing 80 to 100 tons per acre per annum, the estimated produce of the plains not amounting even to one ton per acre. However prolific the prickly comfrey may be in

some climates, it seems not to be suited to the hot, dry seasons of Australia.

In view of the probable exhaustion of the supply of esparto from Algeria and Spain, it is satisfactory to learn, on the authority of Dr. Schomburgk, that there is every prospect of the plant succeeding in South Australia. Under the head of medical plants we learn that a great demand has arisen in South Australia for *Phytolacca decandra*, which is freely used in the homœopathic treatment of diphtheria, a great number of children, it is said, having been saved from death by the influence of the plant.

A branch of cultivation that promises to become of very great importance in South Australia is the systematic growth of perfume plants. Of the magnitude of the commercial aspect of the perfumery trade, we are reminded that British India and Europe consumes about 150,000 gallons of handkerchief perfume yearly, and the English revenue from eau-de-cologne alone is about £8,000 a year; that the total revenue from imported perfumes is estimated at about £40,000, and that one great perfume distillery at Cannes uses yearly about 100,000 lbs. of acacia flowers (*Acacia farnesiana*), 140,000 lbs. of rose petals, 32,000 lbs. of jasmine blossoms, 20,000 lbs. of tuberose, besides a great many other fragrant plants. Dr. Schomburgk says:—"Most of the flowers which provide the material for perfumes grow most luxuriantly with us, viz.: mignonette, sweet verbena, jasmine, rose, lavender, *Acacia farnesiana*, heliotrope, rosemary, peppermint, violets, wallflower, laurel, orange, and the sweet scented geranium. I may say that these plants thrive probably in greater perfection here than in any other part of the world. No doubt South Australia should be a perfume-producing country. We see flourishing here some of the most valuable scent plants, and even some of our native plants will yield a valuable scent; but two things are needed to encourage the enterprise. First, if the scent is manufactured in South Australia, freedom of the still, so as to license distilling in vessels of less than twenty-five gallons capacity, and, secondly, the *bona fide* advertisement of a capitalist manufacturer that he will buy any quantity of specified flowers, leaves, roots, or plants, at a marketable price, then some farmers might be tempted to plant a few acres of lavender or mint; another, géraniums or rosemary; another, jasmine; whilst plantations in hedgerows, or otherwise of roses, cassia, together with contributions of gardens, would lay the foundation of an export trade. Then it must also be noted that whatever the value which plants yield in flowers, fruit, leaves, and stems, it is increased threefold under manufacture, and this manufacture again consumes other local produce called into existence by it, such as olive and other oils, fats, alkalies, wheaten flour, colouring matter, pottery, and glass ware, which combine to make the farmer and the manufacturer contribute largely to the maintenance of the population and the wealth of perfume-producing countries." Dr. Schomburgk further points out the profits likely to accrue from an extended cultivation of scent-bearing plants, as against the cost of land in England, acres of which in certain localities are under cultivation of peppermint, lavender, and other well-known plants of the same class. The failure of these crops, or more particularly those on the farms of Grasse, Cannes, and Nice, would be a serious disaster to this branch of commerce, the importance of which may be proved from the fact, that a member of a well-known perfumery house in Bond-street has thought it worth his while to visit Australia for the purpose of encouraging this branch of culture. Regarding the manufacture of the perfumes, an opinion is expressed which will no doubt be fully endorsed by practical men at home, that it is unadvisable to prepare them in the colony; this work would of course be much more effectually done in this country, at the same time, the plants might go through some manipulation or partial preparation, so as to reduce their bulk and consequent cost of freight. The outcome of this endeavour to open a new branch of commerce with Australia will be looked to with much interest.

The introduction and extended cultivation of the olive (*Olea europea*) in Australia is now *un fait accompli*; it is nevertheless satisfactory to find that a choice variety—that which produces the famous Lucca oil—has been successfully raised. This new introduction seems due to the energy and liberality of a private gentleman, by whom it is hoped the plants will be freely distributed.

Some amount of interest has lately attached to the catalpa tree on account of the great durability of the wood; it is said to resist decay in a marvellous manner, especially when buried in the ground, or placed in contact with the earth; fence posts made of it have stood in the ground forty-six years, and when taken up have shown no signs of decay. Further, a specimen of the wood taken from a post that had stood in the ground for 75 years was perfectly hard and sound, and that part that had been buried showed decay only to the extent of about a quarter of its diameter. The wood is light in weight, of compact fibre, has a handsome grain, takes a brilliant polish, and is well suited for ornamental cabinet work. Trees of four years old have but little sap, and the older ones but a mere film, hardly thicker than paper. They are indigenous in Indiana and other parts of the West, where specimens may be found 4 ft. in diameter near the ground, and with trunks 50 ft. high without a limb. The trees are of very rapid growth. They should be planted thickly, so as to confine the growth to the stem, and after a certain period thinned out. In the Western States, it is being extensively planted, with a view to the future of its timber for railway ties. It is asserted that one rood of land may, in 20 or 30 years, grow trees enough for the owner's use, and, at the same time, thin out and sell enough of the smaller growth, for telegraph poles, fencing, and other purposes, to cover all expenses of growing the tree. The durable nature of the wood is beyond dispute, and from experiments made, thus far, for railway purposes, the catalpa ties proved as firm after a lengthened period under the rails as oak. It is said that a railroad once laid with them would require no renewals to speak of for fifty years, and that in the annual outlay for repairs a very great saving would be effected. It is further stated that in some situations in Pennsylvania the catalpa dies back the first year, or often the second, or if not dying right down it looses its leader, and thus makes the stem crooked. When growing the tree for timber it is advisable to let it grow as it will for two or three years, and then cut it clear to the ground; a clear straight shoot 10 to 15 and even 20 feet high being the result. Trees have been seen that have made a growth 15 feet high and 10 inches round in one season when cut back in this way. The plant here referred to is undoubtedly *Catalpa bignonioides*, a sample of the wood of which, taken from a post that had remained in the ground 75 years, is contained in the Kew Museum, and to all appearances is perfectly sound and as strong as the first day it was put in. The wood, however, is very even grained, of a very pleasant tint, and would no doubt prove useful in this country for various purposes. Dr. Schomburgk tells us that he has taken steps towards securing a quantity of the seeds of this tree for the purpose of extending its cultivation in Australia. On the subject of wattle farming, or the systematic cultivation of the various species of acacia which are known in this colony as wattle trees, Dr. Schomburgk enters into details, inasmuch as its importance to the colony is such that it formed the subject for the attention of a specially organised commission. The *Phylloxera vastatrix*, or vine scourge, also comes in for a large shar of attention, the substance of which, however, has ap-

peared in European journals. The progress made in the Adelaide garden itself is eminently satisfactory, which is shown by the fact of the improvements and enlargements of some of the plant houses, and the introduction of numerous new plants. It is, moreover, satisfactory to learn that the cost of a new building for the collections of economic botany has been granted by the Government.

LONDON WATER SUPPLY.

In the House of Commons. on Wednesday, 13th inst.,

Mr. Fawcett moved the resolution "That, in view of the fact that the Metropolitan Board of Works has been unable to pass any measure dealing with the water supply of London, this House is of opinion that it is a subject which ought, without delay, to be dealt with by the Government."

Mr. Cross, after discussing the three points which had been raised, viz. :—(1) The quality of the water supplied; (2) the mode of the supply; and (3) its cost, said—They were asked to deal with a very difficult question, and could not well draw comparisons between Manchester or Liverpool and London. A vast amount of money had been invested in the stock of the water companies, and if any notion was to go forth that a transaction was to take place, such as that suggested by the hon. member for Hackney, there would be a disturbance in the value of the stocks of the companies which might result in the greatest injury and disappointment. On behalf of the Government, he was prepared to state this: If the motion were carried, he believed it would produce the result to which he had just alluded, but he was as anxious as any one could be that the whole subject should be investigated, and that immediately and in all its bearings, as to whether the water supply could be improved for the benefit of the inhabitants of London; whether, if so, it could be done without seriously increasing the cost of supply to the consumer; whether the mode of supply could not be vastly improved; whether it was necessary for that purpose that the water companies should not, by agreement, surrender their powers to somebody to be appointed by the Government; or whether there was any other mode in which the question could be more satisfactorily dealt with. All he could undertake to say was that before Parliament met again he should take care that an investigation should be made as might lead to such satisfactory conclusion. Under these circumstances, he hoped the hon. member for Hackney would not press his motion to a division. For his part, he could not speak more frankly than he had done. He was perfectly alive to the importance of the subject, and to the necessity for immediate inquiry. There were difficulties to be got ever, but they were not, he thought, such, as could not be surmounted, and he therefore, as he had said, trusted that the hon. member for Hackney would not tie the hands of the Government in the matter by going to a division. To do so at this particular moment would, in his opinion, have a very injurious effect upon the value of the stocks of the water companies. It might raise hopes which could not be realised, and on the other hand in might cause a serious depression in the value of the stocks. He wished only to add that if the Government did undertake a scheme which might be recommended, they would not have regard to any prospective addition to the value of the stocks of the water companies. They would take those stocks as they found them on such a day as say, the last day of the last half-year, and no speculative change in the value of the stocks would have the smallest weight with the Government in any proposal they might have to make. That he wished to be most clearly understood by all those who might desire to deal in the stocks of the water companies either by buying or selling. If the Government undertook any such scheme, they would do so only on the conditions he had stated.

Sir C. Dilke considered the statement of the Home Secretary to be very satisfactory, and hoped that the motion would not be pressed.

Mr. Fawcett then withdrew his resolution.

WATER SUPPLY EXHIBITION.

An Exhibition of appliances relating to water supply was opened at the Alexandra Palace on Thursday, the 14th inst. It is hoped that the Exhibition will form the nucleus of a permanent museum, and maps and other objects illustrating the subject will still be received for exhibition. Mr. Chadwick, who took the chair on the occasion, expressed his opinion that the work undertaken was of the highest value, and alluded to the discussion on the subject of metropolitan water supply in the House of Commons. He then specially referred to the changed attitude of Vestries as an augury of improvement in the future. He had been for a large portion of his life an earnest advocate for the improvement of our water supplies, and he hailed the present attempts as indications of the realisation of his hopes. The Lord Mayor said that it afforded him very great pleasure to inaugurate that most excellent and interesting Exhibition. He very much doubted whether any person holding the office of Lord Mayor could be better employed than in drawing public attention to the great advantages to be derived from a proper supply of good, wholesome, and pure water, and to the vast difficulties which every town in this kingdom had more or less experienced in obtaining that supply. The prospectus rightly stated that the correspondence between the Prince of Wales and the Prime Minister had revived the popular interest in this all-important subject; and, looking round that admirable Exhibition, as he had had the pleasure of doing, he felt certain that the various plans, designs, models, and other appliances so scientifically and ably grouped together would much enlighten the public in the matter. The Exhibition was as simple, on the one hand, as it was scientific and abstruse on the other, and he wished it the great success it deserved.

COPYRIGHT.

Lord John Manners's Bill for consolidating and amending the law relating to copyright, has been issued. According to it the author of a book first published in her Majesty's dominions will be entitled to the copyright throughout those dominions, whether he is a British subject or not, or whether he is domiciled or resident in those dominions or not. With regard to a book first published out of her Majesty's dominions, the provision is that the author may acquire the copyright by republishing it in those dominions within three years from the first publication, if, at the time of the first publication, he is either a British subject or an alien domiciled in her Majesty's dominions. In this case the copyright would date from the publication. The time for the duration of the copyright is thus regulated by the Bill :—If the book be published in the lifetime and under the true name of the author, the copyright would endure for the life of the author and for 30 years after his death; but for 30 years only from the date of the first publication if the book be not published in the author's true name,

or if it be published after his death. With regard to what would constitute an infringement of the copyright, not only would it be illegal to priut a copy of the book without consent, but to print au abridgement or a translation of it, or to dramatise it by preparing or adapting it for representation on the stage as a dramatic piece, or to cause a dramatised version of it to be publicly performed. It is provided that no legal proceedings be taken or forfeiture incurred iu respect of any infringement of copyright until registration has been effected with the Stationers' Company. And to register, the proprietor must deliver to the Registrar a copy of the book, accompanied by a verified statement showing the uame, address, aud calling of the publisher and of the proprietor of the copyright, and the place and date of the first publicatiou. If the author's true name is published, the statement must also include his name, address, and calling. The book thus delivered to the Registrar is directed to be sent on by him to the British Museum. Moreover, it is provided that the assignment of a copyright be invalid unless it be registered; and that every registered proprietor shall have absolute power of disposing of the copyright, with the exception that it is left open for rules to be made for *caveats* being entered against any such disposition. These and other rules for the regulation of registration are to be made by the Board of Trade, subject to the approval of Parliament. In the case of any work published in series, it is provided for the copyright of the whole to beloug to the proprietor, as if he were the author of the whole, when the parts have been composed on the terms that the copyright in the composition shall belong to the proprietor. This rule is, however, subject to certain qualificatious, among which is oue which says that, except with regard to an encyclopædia, the proprietor of the copyright may not publish any of the compositions separately from the rest of the book without the consent of the author. And after three years from the first publication, the right of publishing the compositiou separately would vest exclusively in the author. The provisions of the Bill with respect to books published in series are made to apply to newspapers as regards original compositions of a literary character, but not as regards the portion containing news. One of the provisions directs that the publisher of a newspaper shall send a copy of every number to the British Museum withiu a week of publication. With regard to lectures, it is provided that if they be other than those delivered in a University, public school, college, or public foundation, or by any persou iu virtue of or according to a charity, the author is to be entitled to copyright in them, just as if they were books. It will uot, however, be necessary to register a lecture which is not published. As loug as a lecture has not been printed aud published by the author, a man will infringe the copyright if he delivers the lecture without the written conseut of the proprietor. But a uewspaper is not to be debarred from publishing a report of the lecture in the curreut editiou, unless the author before or at the time of delivering the lecture give notice of a prohibition. The copyright in dramatic pieces or musical compositions, which are either printed and published or publicly performed, is subjected by the Bill to the following rules:—It is an infringement to perform one publicly, or auy part of one, or auy abridgement or adaptation, without the written conseut of the proprietor. If a piece or composition is publicly performed but not printed and published as a book, it may be registered without the delivery of a copy or a statement of the publisher's name. The first public performance or the first publication by printing and publishing as a book, whichever may be the carliest in date, is to be deemed the first "publication." Part 2 of the Bill relates to paintings, sculptures, engraviugs, and photographs; part 3 to colonial copyright; part 4 to foreign copyright; and part 5 contains some general provisions relating to legal proceedings and the like.

GENERAL NOTES.

Science in Schools.—Mr. Twining's series of "Science made Easy" has been used as the foundation for lectures, which have been giveu with great success to the boys at the University College School, and at the Middle-class Schools in Cowper-street. The series (which was noticed in the *Journal*, vol. 24, p. 501) embraces, in ten connected lectures, the fundamental facts and principles of physics, chemistry, natural history, and physiology, and is intended for the instruction of those who are unacquainted with the first principles of science.

Magnetisation of Cast Iron.—Mr. E. Chernoff has succeeded in the curious experiment of magnetising cast iron by surrounding the mould in which the bar was cast by an electro-magnetic reel, along which a current was allowed to flow during the casting process, so that the liquid metal became magnetic and cooled under the influence of the magnetic current. The result was a magnetised bar of white cast iron, but having a symmetrical cavity extending about two-thirds of its length, the metal being extremely thin just opposite the centre of the reel. While pouring in the metal, and until it had set, the experimenter had noticed a singular agitation of the metal, and the hollowness of the bar after setting is explained on the theory of the repulsion of the molten metal toward the poles, the agitation above noticed being a visible evidence of this action. It is suggested that powerful and permanent magnets of cast iron may be obtained in this way by casting under pressure, and that by some modification of the experiment, the plan of magnetising the fluid metal might be usefully employed in casting hollow cylinders without cores.

Electric Light in Mines.—The first electric light employed in the Western American mines was placed on the Deer Creek placer claim of the Excelsior Water Company, at Smartsville, Nevada, on the 10th of last April. A 12,000-candle power Brush machine was put in operation, and three lights of 3,000-candle power each were placed in prominent positions upon the claim. Although the night was very dark, the lights shed a brilliant light around, and enabled the miners to work as readily as during the day. Until this experiment the mines had to shut down during the night, but now the company expects to work both night and day. Nevada and Yuba counties have many hydraulic mining companies, and several of them have announced their desire to use the new light if the Excelsior Company is thoroughly satisfied with their machine. The cost of lighting the claim by electricity is said to be 8d. an hour.

Passengers between England and France.—Reporting on the trade of Calais, Consul Hotham states that the number of passengers passing through Calais in 1878—namely, 260,603—far exceeded the number in any previous year. This, he observes, was to be expected, not only on account of the Paris Exhibition, but also from the success of the new twin-ship *Calais-Douvres*, that vessel alone having carried 56,182 passengers between June and the 2nd of November, 1878, at which last date she ceased running for the season. The Consul reports the number of passengers between England and France through the principal channel ports in 1878 at no less than 600,105—namely, 298,552 landed in France, and 301,553 embarked. The 260,603 passengers *via* Calais show the marked preference for the Calais route. There were also 144,838 *via* Boulogne, 140,007 *via* Dieppe, 26,258 *via* Havre, 991 *via* Dunkirk, to which are added 27,408 *via* Ostend.

NATIONAL WATER SUPPLY, SEWAGE AND HEALTH.

The report of the Conference held in May last is now ready, and can be obtained at the Society's House, price 1s. 6d. paper, 2s. boards with cloth back.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

GROSVENOR HOUSE.

The Duke of Westminster is desirous that designers, artisans, and the like, employed in any branch of Art applied to productive industry, should have the opportunity of inspecting Grosvenor House, with its Works of Art, daily, including Sundays, during the months of August and September, 1879, from 2 p.m. to 6 p.m. He regrets that, for want of room, he cannot extend the admission beyond the persons specified.

A number of tickets of admission have been placed in the hands of the Secretary of the Society, for distribution among persons answering to the above description.

Such persons can obtain tickets on application at the Society's house, by bringing with them a paper containing their names, addresses, and occupations.

Each ticket admits a party of four.

There will be no admission on wet afternoons.

HEALTH AND SEWAGE OF TOWNS.

NOTES OF PROGRESS WITH SEWAGE SINCE THE FIRST CONGRESS OF THE SOCIETY OF ARTS IN 1876, SUBMITTED TO THE FOURTH CONGRESS IN 1879.

By Sir Henry Cole, K.C.B.

1. The Rt. Hon. James Stansfeld, late President of the Local Government Board, has delivered three addresses at the Conferences on Sewage, which have taken place in this room. These addresses, for the soundness of their doctrine and advice and useful suggestions, might well be repeated on this occasion. They are silently, although too slowly, bearing fruit. But there was one suggestion of paramount importance, and not difficult to carry out, to which I would call attention, in the hope that we may see it accomplished before our next Conference.

2. Mr. Stansfeld suggested that there should be an *Inquiry Department*, where any one could go to put any question on Sewage in the interest of the town he represented, and get the best possible answer, and he said, if the Local Government Board did not institute it, the Society of Arts might. But neither Government nor Society have as yet acted on this sound advice given in 1876.

3. The public ignorance on sewage subjects is still universal and deep, but is becoming less so. In London, the majority of houses are not properly connected with the main sewers, although four millions have been spent on the sewers, and our vestry masters cannot show to a proposing tenant what the state of the connexion is in the majority of houses. Houses, when connected, are generally but a ventilating shaft for sewer gas everywhere. I have lived in four furnished houses, during my provincial inquiries, in the last two years, and every house was a ventilating shaft for sewer gas. But the difference between London and the provinces is, that Birmingham and Manchester, with admirable promptness, compel the landlord to expel the demon of typhoid fever, whilst London allows him to remain.

4. I proceed to give a few important instances of how little progress has been made since the Conferences began. Our chairman said, in 1876, that the Congresses were intended to take stock year after year of the experience of the country. I propose to take a little stock of how the country now stands, and notice a very few marked examples.

5. In our principal City, with its four millions of people, the Thames in the metropolis remains as foul as ever. When Parliament could bear it no longer, lime, unlimited in quantity, could be used to purify the sewage at the West-end. The Metropolitan Board of Works affects to say that Sewage at the East-end does not require purification. The Thames Conservancy Board, it is said, are taking slow legal measures to correct the views of the Metropolitan Board of Works, but the Board makes no sign of doing anything; whilst it flinches from asking the metropolitan ratepayers for even a penny a year for effectually getting rid of the impurities. In the upper part of the Thames, the results of the different plans adopted at Oxford, Reading, and Windsor, are not sufficiently ascertained to be discussed, but doubts are expressed of their success. In the Lower Thames Valley district the attempt to place a sewage farm between Hampton-court and Claremont has been discouraged by the House of Commons, and the Bill not even allowed to be discussed.

6. In large provincial towns, passiveness only appears to reign. Birmingham (with its 360,000 population) goes on with precipitation and digging the sludge into the land, and it makes the best effluent it can; but it may be doubted if it comes up to an authoritative standard of purity. It is tolerated by Lord Norton, however. Manchester has plans for a federation of places in the immediate suburbs, but it has no settled scheme of purification. Until Oldham and other great towns, now polluting the rivers which flow through Manchester, act, it would be useless for Manchester to attempt a purification. In the meantime, a little place, Withington, with 20,000 inhabitants, has been permitted to borrow money to forward the commencement of a sewage farm in the midst of a populous neighbourhood! Salford, with 140,000 people, has done nothing. Leeds, with 300,000 people, goes

on accumulating its sludge by hundreds of tons. Glasgow, with nearly half a million of people, proposes to use precipitation, and take the sludge down the Clyde to the sea. Leicester cannot decide what to do with its sludge. Facts connected with 100 places, having about three millions of population, have been collected and are appended to this paper. It is typical of the state of public paralysis.

7. Only eleven places, out of about 70 addressed by the Society of Arts, have sent in returns relating to Irrigation for the use of this Congress, and they give no important information. Wolverhampton (75,000 population) is said to have found out that it is quite possible to overdose the land with dirty sewage, and is looking out for more land to give rest to its present farms.

8. Two or three conclusions respecting farming by sewage now seem to be admitted. 1. That the storm water must be kept out of the sewers; 2. That precipitation must take place before the sewage flows on the land; 3. That filtration of some kind after precipitation is most desirable; 4. Another conclusion is, that towns cannot make a profit out of water-carried sewage, a fallacy which haunts old-fashioned minds, especially in the Metropolitan Board. I believe Croydon and Stoke-on-Trent are likely to show new combinations of treatments, which may be useful.

9. Compulsory federation of small places under a united local management is a subject which, I think, is ripe for the Local Government Board at once to insist on. The Duke of Sutherland, who, among great landlords, has taken a prominent and patriotic part in overcoming the sewage difficulties, addressed a letter, which I am permitted to quote, to the President of the Local Government Board. It is as follows:—

Letter sent by the Duke of Sutherland to the Right Hon. G. Sclater-Booth, President of the Local Government Board.

28th January, 1879.

Sir,—The two printed documents which accompany this letter relate to the purification and conservancy of rivers in Lancashire, and have come before me. Whilst I feel myself justified, on public grounds, in sending them to you for the consideration of the Local Government Board, I do so all the more, because I have personal evidence of the delays and bad results of the want of union and co-operation in the various towns of the Potteries in dealing with the pollution of the River Trent by sewage, which passes through my property.

Places in Lancashire, as in other counties, have hesitated to comply with the law prohibiting the pollution of rivers, partly because they shrunk from the necessary expenditure, and partly because the purification of one or two places on a river was of little use, unless along the whole course of the river. A glance at the sketch map of the Irkwell basin (published in the report of the Rivers Pollution Commisssioners) forcibly illustrates this fact. For example, the unpurified sewage of Oldham finds its way through the Irk and Medlock to Manchester. The sewage of Bolton, Bury, and of Rochdale, &c., all descend, by the Irwell, through Salford and Manchester. Unless each of these purifies its own sewage, the law cannot equitably be enforced on Manchester and Salford. This seems a special case where the direct intervention of the Local Government Board, to act simultaneously, is called for on every account; and I venture to express my conviction to you, of the urgent public policy of advising Oldham to act at once in purifying the sewage of its own locality, and bringing into federation the small adjacent places. It would seem desirable that a limited period should be fixed for accomplishing the work. If this advice were given by the Local Government Board, I believe Manchester and Salford would then proceed with their own duty of purification, and a useful example to all places in Lancashire and Yorkshire would be set.

Having regard to the great magnitude of the work, and my interest in its national importance, I hope you will not think I am carried too far if I ask you to consider the expediency of constituting some organisation in Lancashire, which, in friendly communication with all places, might aid in inducing Lancashire, in its respective catchment basins, to unite in laying out, without further delay, the several necessary schemes for purifying the rivers of the sewage.

By adopting the principles of federation, I am convinced that a great benefit would be conferred on the several millions of the people congregated in the manufacturing places of the North of England, which constitute a large proportion of the country; whilst, without such stimulus, experience has shown that the work may continue undone for years. Conservancy over rivers, which the Committee of the House of Lords recommended in 1877, seems inevitable in the progress of sanitary improvement, and some preliminary inquiries and action would appear to be a useful preparation for introducing that necessary conservancy of rivers.* I am, &c.,

Sutherland.

The answer of the Board was favourable, but it stopped short of adopting compulsory action.

Local Government Board, Whitehall, S.W.
4th March, 1879.

My Lord Duke,—I am directed by the Local Government Board to state that they have considered the representations contained in your Grace's letter of the 28th of January last, and they wish to observe that they are always ready to give attention to any application, which may be made to them for the formation of any large united district for purposes of sewage disposal, under Section 279 of the Public Health Act, 1875. Moreover, they are also ready at all times to render any assistance in their power to local authorities who wish to combine for these purposes, under Section 285 of the Act. Some combinations have already been formed under both of these enactments, and the Board have now before them some cases in which it is proposed that like combinations should be formed under one or other of the sections in question.

At the same time the Board's experience leads them to believe that, generally speaking, it is desirable for them to wait until their assistance is sought, by one or more of the sanitary authorities proposing to form a combination, before they interfere in the matter; and it must be borne in mind that the Board have no power to compel a combination under Section 285, and that they can only proceed under Section 279 upon the application of one of the sanitary authorities interested.

The Board have not at present received any such application with respect to any of the places to which your Grace refers, but with regard to some of these places, they have before them matters which involve the question of sewage purification.

In dealing with these matters, the Board will not fail to give consideration to the views expressed by your Grace as to the desirability of a combination of authorities being formed to deal with the disposal of the sewage.

I have the honour to be, my Lord Duke,
Your Grace's obedient servant,
(Signed) John Lambert, Secretary.

To His Grace the Duke of Sutherland, K.G.

* A Bill has passed the House of Lords this Session.

10. An opinion has been expressed by civil engineers of knowledge and experience, that sanitary science has been retarded by the antiquated prejudices of the Inspectors of the Local Government Board in favour of Irrigation. A late President of the Institute of Civil Engineers once said to me :—"The simple result of the utilisation of Sewage by Irrigation is the production of a penny cabbage at the cost of sixpence, and a pestilential neighbourhood besides."

11. The risks of sewage irrigation of the Local Government Board were exposed in the Report of 1876, when the following cautions were issued:—

"Land irrigation is not practicable in all cases, and therefore other modes of dealing with sewage must be allowed.—(p. xiii.)

"The continuous application of town sewage to all soils is by no means an unalloyed benefit, as in some cases and seasons, and especially upon dry land, it may be rather injurious than otherwise. Very few crops are actually benefited by the direct application of sewage upon a stiff and retentive soil; indeed, Italian rye grass, cabbage, and mangold wurzel seem to be the only farm crops that persistently flourish upon any soils, heavy or light, under continual doses of town sewage. . . . . The cultivation of sewaged land, for instance, requires more than double the amount of manual labour which is usually employed upon arable land, and more horses must be kept than upon an ordinary farm. . . . . To properly stock and work a sewage farm, upon which the main produce is consumed, quite five times the usual amount of money will be needed. One of the greatest difficulties is to keep the sewaged land clean."

"We have been also assured by a gentleman of vast experience that the long-continued application of sewage to the same land fails to produce the like beneficial effect as when it was first used."

"Most sewage farms are at present under the control of ever-changing Town Councils and Local Boards, whose members must, as a rule, be ignorant of practical agriculture." (p. xxxvi). "Disappointment has therefore been expressed at the poor financial results of sewage farms."

Notwithstanding the official publication of these views, some Inspectors of the Board continued to insist upon the acquisition of land, in unnecessary quantities, as the first condition of recommending a loan. When in Manchester last year, two cases were brought to my notice, and I was impelled to call the attention of the Local Government Board to reports, published in the Manchester newspapers, of the observations of inspectors made at local inquiries on the quantity of land required for purification of sewage. I received an official answer, dated 6th February, 1879, stating, "that the President can only say that the inspectors are instructed not to express publicly any opinion upon the proposals into which they have to inquire, except in those cases when the views of the Board have been distinctly ascertained on the subject, and the Board themselves are always very careful to abstain from advising local authorities as to the particular scheme which they ought to adopt. In fact, when the Board are applied to for advice as to the sewage of a district, they invariably recommend the local authority to call in and consult some competent engineer, and point out to them that it is only when plans have been prepared, and a loan is required, that the Board will be in a position to consider the matter. Of course, when application is made to the Board to sanction loans for works, it is requisite that they should take all necessary precautions to satisfy themselves that the works will be effectual; but so far from discouraging scientific progress, they are only too glad to have brought under their notice any scheme which can be reasonably relied upon as combining economy with efficiency in dealing with the difficult question of sewage disposal."

12. Nothing can be more satisfactory than this declaration of principles which, I believe, will prove of the highest value to the progress of sanitary science, and I rejoice that I have the opportunity of thanking Mr. Sclater-Booth, the President of the Local Government Board, for it. I am sure it will be most acceptable and encouraging to the sanitary engineers throughout the country.

13. In the present state of public opinion and knowledge, I submit that strong compulsory legislation, to deal with the science of sanitation, is hardly possible, and not desirable. In sanitary as in other subjects, Government in this country must follow, and not lead, public opinion; and it can never be dogmatic in science. But as the public mind becomes made up for action, it seems that the Government should itself act promptly. Federation of small places, with central local action, may be insisted on, and compulsory prohibition against polluting the Thames seems to me a case where Government may say at once, "This must be no longer."

APPENDIX.

Confederation of Places in Catchment Basins of Rivers to Promote the Economical Purification of Sewage.

Places on the Rivers, Streams, and Watercourses in the Irwell, Mersey, Ribble, and Calder Catchment Basins, having 5,000 inhabitants and upwards, and the present state of their sewage.

The facts stated are compiled from Lord Rosebery's Parliamentary Return, 1876; Local Government Directory, 1877, and various Sanitary Reports of the Society of Arts, &c., and have been submitted for correction to the several local authorities.

Irwell Basin.

Astley Bridge.—Population, 6,000; rateable value, £23,174; Astley Brook into Croal. No return.

Audenshaw.—Population, 6,000; rateable value, £16,500; Tame. Some sewage scheme authorised by Local Government Board in process of execution.

Bacup.—Population, 29,000; rateable value, £83,017; Irwell. No return.

Barton Eccles.—Population, 19,000; rateable value, £70,000; Irwell. Nothing done.

Bolton. — Population, 105,000; rateable value, £296,646; Croal, Tonge, and Irwell. Bolton has a lime precipitation scheme, but has difficulty in disposing of the sludge.

Bradford. — Population, 14,000; rateable value, £27,643; Medlock. No return.

Bury.—Population, 52,000; rateable value, £210,063; Roach and Irwell. Nothing done. Drainage plans preparing by Mr. Cartwright, Borough Surveyor.

Castleton by Rochdale.—Population, 4,000; rateable value, £23,000; Roach. Nothing done. Mr. Farrar, C.E., is preparing plans.

Chadderton.—Population, 14,200; rateable value, £60,001; Irk. Nothing done.

Crompton (near Oldham.)—Population, 7,300; rate-

able value, £29,745; Roach, Irk, and Beal. Nothing done. Mr. Farrar, C.E., is preparing plans.

Crumpsall. — Population, 5,340; rateable value, £23,751; Irk. Nothing done.

Droylsden. — Population, 6,678; rateable value, £21,374; Medlock. Nothing done. This district has been in correspondence with the Manchester Corporation, and may, with other adjoining districts, be included in their scheme.

Failsworth. — Population, 6,800; rateable value, £29,264; Moston Brook into Irk. Nothing done as yet.

Farnworth.—Population, 22,000; rateable value, £56,000; Croal. No return.

Gorton.—Population, 31,000; rateable value, £89,798; Irwell and Mersey. Nothing done.

Halliwell.—Population, 10,000; rateable value, £40,540; Astley Brook into Croal. Nothing done. Incorporated.

Haslingden.—Population, 13,000; rateable value, £40,020; Irwell. Nothing done. Mr. Farrar, C.E., has prepared plans. Works in progress.

Heywood. — Population, 23,000; rateable value, £97,903; now drained under Mr. Farrar, C.E.

Kearsley. — Population, 5,950; rateable value, £28,548; Irwell. Nothing done.

Littleborough.—Population, 8,500; rateable value, £31,300; Roach. Nothing done. Drainage begun under Mr. Shuttleworth, Local Board Surveyor.

Little Lever.—Population, 4,204; rateable value, £18,218; Irwell. Mr. Garrar, C.E., has prepared plans.

Manchester.—Population, 351,180; rateable value, £2,125,759. Plans prepared by Mr. Bateman and Mr. Lynde. They include a treatment of the sewage on north side of Harpurhey (Irk); Newton (Shootersbrook, population, 22,000). On south side, of Rusholme (Irwell, population, 10,670). Moss Side (Irwell, population, 12,500), Levenshulme (population, 2,500); Withington (Irwell); Stretford (Irwell, population, 19,000); and Barton-on-Irwell (population, 19,000). On the west side, Droylsden (Medlock, population, 6,678); Openshaw (Gorton Brook, population, 13,500); Gorton (Irwell, population, 31,000).

Middleton. — Population, 14,580; rateable value, £36,461; Irk. Nothing done.

Milnrow. — Population, 6,700; rateable value, £19,751; Beal. Nothing done.

Moss-side. — Population, 12,500; rateable value, £63,151; Irwell. Nothing done.

Newton Heath. — Population, 25,000; rateable value, £86,552; Medlock.

Oldham. — Population, 100,000; rateable value, £393,579; Irk and Medlock. Nothing done.

Prestwich. — Population, 6,820; rateable value, £32,084; Irwell. Nothing done.

Radcliffe. — Population, 15,000; rateable value, £71,402; Irwell. Drainage commenced under Mr. Farrar, C.E. Drainage on hand now.

Rawtenstall.—Population, 13,000; rateable value, £57,174; Irwell. Nothing done.

Rochdale. — Population, 68,650; rateable value, £279,623; Roach and Spodden. Nothing done. Drainage plans preparing by Mr. Hewson, Borough Surveyor.

Royton.—Population, 8,000; rateable value, £27,032; Irk. Nothing done.

Rusholme. — Population, 10,670; rateable value, £72,353; Irwell and Mersey. Nothing done.

Salford. — Population, 138,890; rateable value, £749,632; Irwell.

Stretford.—Population, 19,000; rateable value, £108,000; Irwell. Nothing done. A small settling tank is fixed on the banks of the Mersey for the village portion of sewage.

Swinton and Pendlebury. — Population, 20,000; rateable value, £67,907; Irwell. Nothing done. Messrs. Brockbank, Wilson, and Mulliner are preparing plans.

Whitefield.—Population, 9,800; rateable value, £39,412; Irwell. Drainage begun under Mr. Farrar, C.E.

Whitworth.—Population, 11,000; rateable value, £38,218; Spodden. Nothing done. (48 places.)

Mersey Basin.

Ashton in Makerfield.—Population, 9,000; rateable value, £47,000; Down Brook and Millingford Brook, tributary of Mersey. The Ashton Local Board have carried out an irrigation scheme.

Ashton on Mersey.—Population, 10,000; Mersey. Drainage commenced under Mr. Newton, C.E.

Ashton-under-Lyne.—Population, 31,980; rateable value, £101,437; Tame polluted and flows into Mersey.

Atherton. — Population, 10,200; rateable value, £40,600; various brooks into Mersey. Main sewers and Lime Precipitation Works on the point of completion.

Birkenhead.—Population, 55,000; rateable value, £232,312; Mersey. Nothing done.

Bootle-cum Linacre.—Population, 24,500; rateable value, £116,102; Mersey. Nothing done.

Cheadle. — Population, 6,000; rateable value, £40,000; Micker Brook and Mersey. Nothing done. Plans prepared by R. Vawser, C.E.

Denton.—Population, 6,000; rateable value, £19,644; Mersey. Nothing done.

Dukinfield.—Population, 16,000; rateable value, £54,378; Tame polluted into Mersey. Mr. Cartwright, C.E., has prepared plans for intercepting sewers.

Garston. — Population, 8,500; rateable value, £55,440; Mersey. Nothing done.

Haydock. — Population, 5,280; rateable value, £18,763; Sankey Brook into Mersey. Nothing done.

Heaton Norris.—Population, 5,500; rateable value, £26,995; Mersey. Drainage commenced under Mr. J. H. Lynde, C.E. Main drainage estimated to cost about £15,000. No system of purification as yet adopted.

Hindley.—Population, 10,620; rateable value, £54,190; Bosdane Brook into Mersey. Nothing done.

Hurst.—Population, 5,650; rateable value, £15,000; Hurst Brook pollutes the Tame. Nothing done.

Hyde.—Population, 14,223; rateable value, £54,000; Tame. Nothing done. Plans prepared by R. Vawser, C.E.

Leigh.—Population, 19,700; rateable value, £61,799; Glazebrook tributary of Mersey. Nothing done.

Liverpool.—Population, 521,500; rateable value, £3,000,395; Mersey. Nothing done.

Macclesfield.—Population, 35,571; rateable value, £78,079; Bollin into Mersey. Nothing done.

Mossley.—Population, 15,000; rateable value; £36,000; Tame polluted into Mersey. Nothing done.

Newton in Makerfield.—Population, 9,000; rateable value, £38,000; Newton Brook, Sankey Brook into Mersey. Nothing done.

Prescot.—Population, 5,990; rateable value, £11,682; Prescot Brook by Sankey Brook into Mersey.

Runcorn.—Population, 14,000; rateable value, £39,613; Mersey. Nothing done.

St. Helens.—Population, 50,000; rateable value, £188,795; Sankey Brook into Mersey. Nothing done.

Sale.—Population, 5,573; rateable value, £44,162; Mersey. No system of treatment.

Stalybridge.—Population, 21,040; rateable value, £70,000; Tame polluted into Mersey. Nothing done.

Stockport.—Population, 53,001; rateable value, £161,687; Mersey. No system of treatment.

Toxteth-park.—Population, 7,000; rateable value, £60,281; Mersey. Nothing done.

Tranmere.—Population, 17,478; rateable value, £66,972; Mersey. Nothing done.

Tyldesley. — Population, 8650; rateable value, £40,132; Hindsford Brook into Mersey. Nothing

done. Has an irrigation scheme prepared. Plans prepared by R. Vawser, C.E. Application has been made for sanction to borrow £30,000, for the purchase of land for sewage irrigation, and for main drains.

WALLASEY.—Population, 14,819; rateable value, £95,599; Mersey. Nothing done.

WARRINGTON.—Population, 40,000; rateable value, £125,228; Mersey polluted. Nothing done.

WATERLOO WITH SEAFORTH.—Population, 7,000; rateable value, £47,124; Mersey. Nothing done.

WAVERTREE.—Population, 8,000; rateable value, £73,887; Mersey. Nothing done.

WEST DERBY.—Population, 31,400; rateable value, £166,758; Mersey and Alt. Has a sewage farm to which the sewage of the greater part of the district is taken. The sewage of a small part only of the district, goes into the Mersey through the sewers of Liverpool.

WESTHOUGHTON.—Population, 8,220; rateable value, £31,176; Brooks into Mersey. Nothing done.

WIDNES.—Population, 20,000; rateable value, £86,156; Mersey polluted. Nothing done. (37 places.)

Ribble and Calder Basin with Pendle Water, &c.

ACCRINGTON.—Population, 34,000; rateable value, £80,241; Hyndburn River and Accrington Brook. Sewage water disinfected with McDougall's fluid.

BLACKBURN.—Population, 90,000; rateable value, £247,104; Darwen tributary of the Ribble.

BURNLEY.—Population, 49,000; rateable value, £112,185; Brun, Calder, and Pendle. Purified by Scott's process.

CHORLEY.—Population, 18,000; rateable value, £56,352; Yarrow into Douglas and Ribble. Irrigation.

CLAYTON-LE-MOORS.—Population, 6,500; rateable value, £15,928; Hyndburn. Nothing done.

CLITHEROE.—Population, 8,217; rateable value, £26,136; Wilkin Brook tributary of the Ribble. Nothing done.

GREAT HARWOOD.—Population, 5,500; rateable value, £14,000; Hyndburn. Nothing done.

OVER DARWEN.—Population, 25,000; rateable value, £66,778; Darwen.

PADIHAM AND HAPTON.—Population, 9,000; rateable value, £17,200; Calder. Nothing done.

PRESTON.—Population, 85,428; rateable value, £247,110; Ribble. Nothing done.

TODMORDEN.—Population, 25,000; rateable value, £64,475; Calder polluted. Nothing done.

WIGAN.—Population, 42,000; rateable value, £114,064; Douglas. Nothing done. [13 places. Total, 98 places.]

NOTE.—The numbers of the population and the amount of the rateable value, taken from the Local Government Directory of 1877, should be considered only as approximate. In numerous cases the population given in the Local Government Directory differs from Lord Rosebery's return.

COURSE OF INQUIRY AS TO WORKS OF SANITATION, AND AS TO THEIR EXPENSE AND RESULTS.

By Edwin Chadwick, C.B.

On the occasion of my attendance at the Sanitary Congress on Hygiene, held at Brussels in 1877, I had the honour of some communication with his Majesty the King of the Belgians, who takes a special interest in the means of improving the health of the population. In answer to the inquiries as to results practically obtained from sanitary works in England, I submitted that it would be more satisfactory, with a view to any practical application in Belgium, if they could be examined and reported upon by Belgian sanitary officers; and I volunteered my services in aid of such examinations, and in pointing out defects which subsequent experience had shown to be removable. This suggestion was acted upon, and Dr. Kenrurd, an officer of the Health Department, was sent over to make the inquiries suggested. We visited Croydon and Bedford together, and received every aid from the authorities there. The following is a copy of a joint report on the course of the inquiry, and of the results obtained. These, I consider to be to some extent incomplete, as respects some important particulars, which arose from the circumstance of the Belgian officer not speaking English; and being a medical officer, conversant with curative rather than preventive science; and not being able to put the questions for himself as to the details of work, I have suggested that, for further and more complete examination as to works and their application to the Belgian cities, the service of a sanitary engineer would be requisite.

For such a course of examination, the first objective points were, to ascertain—First, what had not been done; next, what had been done only imperfectly; and then, what had been done, and might be repeated completely. I have recommended to the Indian Government a similar course of inquiry, and have volunteered to assist any of their officers for its prosecution, for the avoidance of such losses as those of which we have widely-spread examples, of waste from works on utterly false principles, as well as from the misapplication or the defective execution of works on what I deem the sound principles, most fully elaborated under our Sanitary Commissions, and under the first General Board of Health. In our Colonies, and in the United States, there has been extensive, wasteful, and pernicious error in works for the sanitation of cities, which have failed in the commensurate reduction of sickness and death-rates that would have been insured by complete works. Mons. Mille, the *Ingénieur-en-Chef* of Paris, in a report on the sanitary works of Berlin, states that they had been derived by the German engineers from a study of the works devised by our Board, and we know they had visited England for the purpose. The works now in progress in Berlin were devised upon such study, and it is to be hoped that they will present examples of its completeness.

CROYDON.

We visited Croydon, where we had the advantage of the information of Dr. Carpenter, a distinguished physician and for twenty years a member of the Local Board of Health, who, having paid very special attention to the sanitation of the district, is considered to be well versed in the sciences applicable to it. With him, we visited the sewage farm, and saw and received information from the farmer. We also made inquiries on engineering points, from Mr. Walker, the engineer at present in charge of the district. From these sources we received an outline sketch of the sanitary position of the district, which has been filled up by subsequent inquiries as to some of the particulars.

Croydon is about 10 miles from London, and, as it can be reached in half-an-hour by railway, it is almost a suburb of the metropolis. It is, however, in fact a city with a population between that of Bruges and Liege, or about 66,000. In 1879, in consequence of the low state of health of the population, denoted by a death-rate of 28 per 1,000, notwithstanding its advantages, and, in many respects, open position, it was made the subject

of an inquiry by the First General Board of Health. It was subject to severe epidemic visitations. The general causes of insalubrity were then stated to be—inferior water supplies, bad drainage, the crowding of the houses, the surface of the streets, and the supersaturation of the subsoil with wet and excrementary matter. The principles of the remedies recommended by the General Board of Health were—constant supplies of better water carried into the houses, the foul or waste water to be carried away from the houses by a system of self-cleansing house-drains and self-cleansing sewers, and the constant application of all the filth as manurial water for, vegetable production, upon the land. The application of these principles by special sanitary works was unavoidably left very much to the local authorities. It has been the snbject of complaint that they have been applied by them in a very unskilful, defective, and expensive manner; nevertheless, it is admitted that, to the extent to which they have been applied, they have been productive of considerable advantage. The reputation of the new works rendered residence in the town popular, and contributed to nearly a fourfold increase of the popnlation, since that time when it was only 18,000. Had the sanitary condition of the town remained as it was, the sanitary evils must have been considerably aggravated, residence in it rendered more dangerous, and the increase could not have gone on. In 1866, an official inquiry was made into the results obtained, when it appeared, on a comparison with those of the six years preceding the new works, that the proportions of cases of continued fevers had been reduced from 16½ to 5 per cent.; of diarrhœa, from 10 to 7 per cent.; of measles, from 8 to 3 per cent.; of scarlatina, from 8½ to 7 per cent.; of phthisis, from 59½ to 49 per cent.; and of the general death-rate, from 237 per 10,000 to 120. It is still considered, however, that the extent of fever and the occurrence of epidemics in the town is a just subject of complaint, and that this arises from the continued defects of the works. The present position of the drainage works is shown by the following questions put to, and the answers given by, the engineer:—

Q. It appears from the stated accounts, that at the time when Croydon was brought under the cognisance of the first General Board of Health, there were only 300 water-closets. Of the 14,000 houses, how many are now water-closeted?—*A.* All.

Q. Within what time, as far as you can judge, will the excreta of the morning be taken from these 14,000 houses, and a population of 64,000, to the main outfall?—*A.* The bulk of it would be discharged in about one hour, but from the farthest point, which is about three miles, it would be about four hours. The whole, then, would be discharged in about a quarter of a day.

Q. Is the whole system of pipe sewers now perfectly self-cleansing, or free from deposit?—*A.* We have exceptional cases where that is not so, arising from defective work, from bad joints (which let out the sewage and leave deposit), and, in some places, from the bad laying of the pipes—too level, with too little fall. We are now relaying them. In some instances they were so unskilfully laid as to run the wrong way. Some of this work was done by the owners, who employed unskilful hands. Much of the piping, too, was laid, without due precautions, on "made ground;" that is to say, on strata disturbed for building operations, and sunk out of level or broken from want of proper support, such as it has been the practice to give by bedding in concrete.

Q. If the entire work were done *de novo*, and with the present experience, would not the whole system be made self-cleansing?—*A.* Certainly. We should do the work much better, with better falls and better joints.

Q. Then you would have the whole perfectly self-cleansing, even on dry-weather days?—*A.* Yes; certainly.

Q. How as to the house drainage?—*A.* Much of it is very defective, but we are improving it. In many of the houses, the imperfect jointing of the pipe-drains allowed fæcal matter to permeate the basement and the site. Others have had old brick-drains, and defective work of various sorts.

In answer to further questions, it was admitted that, sanitarily, it is far more important to have self-cleansing sewers, the putrid and decomposing deposit within the house having a more direct action by the discharge of noxious gases than the putrid deposit outside the house in the sewer.

Q. It has been stated that, wherever there have been cases here of a typhoid character, there has been invariably some connection with bad drainage work, inside or outside the houses.—*A.* As a general rule, that is undoubtedly so.

Q. Then it will follow that, for the proper protection of a city, or the proper completion of a system of water carriage, there must not only be a complete system of self-cleansing sewers, but a complete system of self-cleansing house drainage?—*A.* Evidently.

Q. Do you exclude storm-water from your sewers?—*A.* Yes, as much as we can, and we are extending duplicate sewers for the purpose. We are doing this in order to rednce the bulk of the sewage in times of storm, and to render it more manageable for agricultural use. Some time since storm water was not excluded, but we have found out our mistake.

Q. As to the cost of the water-carriage system, if it were done *de novo*, inclnding the supply of the house, the internal apparatus of water distribution, the return of the waste or foul water from the kitchen sinks and water-closet, would it amount to more than threepence half-penny per week?—*A.* Since the tubular system of drainage was introduced, the price of labour has been increased, but the price of the materials, the earthenware pipes and iron, have been reduced, and it may be taken at little more than that.

Q. In addition to this work of water-carriage, there is the cost of the removal of the cinders and solid refuse, which was not removed by water-carriage. How much does this cost?—*A.* The cost of this removal, fortnightly, is about 3s. 4d. per annum per house. This would amount to about ¾d. per week.

Q. A number of distant cottages are cleaned on the tub system, which includes, it appears, the fæces. How much does this cost?—*A.* The cost of this removal weekly is £1 per annum, or 4½d. per week, but this does not include the removal of the liquified refnse of the house, the kitchen slops and the fouled water which, after passing through a filter, is there passed into the river.

Q. Under this system the fæcal matter is necessarily retained for days, *i.e.*, for a time when it mnst often enter into putrefactive decomposition?—*A.* Yes, for I am unaware that they use any disinfectant, except it be sawdust.

Q. In the case of the water-carriage from the water-closet, the removal from the chamber or from beneath the house is within the minnte?—*A.* Yes, certainly.

It is to be explained that the whole of the water distributed into houses, here and in London, averages 33 gallons per head of population; or, as there are nsually five persons to each house, there will be 165 gallons per honse carried in; and when the tubular system is impermeable and complete, the same quantity, or 1,650 lbs., must be carried away as fouled water out of the house and beyond the site of the city. By the water-carriage system, this is accomplished at a rate of a halfpenny a day. Half that quantity would be beyond any ordinary domestic labour to accomplish, but of this mass of liquid the water-closet consumes, for the work of the removal of the excreta, not more than some five gallons to remove about 2½ lb. of excremental matter per head of the population, or about 12½ lb. per house. Mr. Robert Rawlinson, the chief sanitary engineer of the Government, has stated that the expense of a soil-pan of the nature of a

water-closet, with the soil-pipe attachment to the drain from the waste or fouled water, or the sink, may be placed for £1 10s. each. The interest on this extra construction, and the expense of the extra quantity of water used for the closet, may be reckoned at 2s. per house per annum; that is to say, at about one halfpenny per week, or little more than one-tenth the expense of removal here, by hand labour, with the cart and the tub, after the sale of the manure carried away in the solid form, in which form the farmer pays 2s. 6d. per ton for it.

The Rivers Pollution Commissioners, on analysing the effluent water of cities which were all water-closeted, found that the proportion of the manurial matter was about one-fifth more in quantity than the refuse from the non-water-closeted cities. Four-fifths of the manurial matter of the house consists of the kitchen refuse, dish washings, soapsuds from clothes washing and personal ablutions, and such other soluble matter as is carried away through the sinks. Four-fifths of the manure of the cottages in question would, therefore, be discharged into the stream.

The difference in the productive power of the special manure from the tub and the whole of the manure removed by water carriage, would be a subject for a distinct inquiry. But the solid manure is used by the market gardeners, or for the *cultures maraichère* or *potagère*, the most productive of agriculture, and they apply it at the rate of 60 tons per acre, in two dressings, per annum.

Whilst the yield of the common agriculture in England is as one, the yield on similar areas from the market garden culture, with such amounts of manure, near Croydon, was stated to be three and a half; but it was stated that the yield of the sewage farm is much greater, and approaches to five. The best grazing land known carries one head of cattle, but the liquified manure farm at Croydon, it is estimated, carries five; that is to say, that the Italian rye-grass, and mangolds, and turnips grown there feed that number of cattle. The quality of the grass is shown by the different quantities of cream derived from the milk produced from different cultures; thus, the proportion of cream yielded from the sewage-fed grass is stated to be about 15 per cent., whilst that given from ordinary pastures is stated to be only about 10 per cent. It may here be observed that Dr. Carpenter has stated, in a report, what is the effect upon the health of the district in which the farm is situated:—"The last return of vital statistics shows that 26 deaths and 60 births have been registered as occurring in the sub-district during the past half-year. This fact bears a most important relation to the working of the farm. The neighbourhood is yearly increasing in population, rateable value, and general health, notwithstanding the fact that, during the past year, the farm has had to provide for and utilise the sewage of a very large number of persons who have suffered from typhoid fever—a fever which has been mainly induced in Croydon through an interference with the water supply of the district. The births in Croydon itself, for the month ending April 29th last, have been 96; whilst the deaths have numbered 35, and typhoid is now entirely absent from the list. The farm has, however, utilised and rendered innocuous all the typhoid excreta from more than 1,000 cases, which have reached it since January, 1875, without the least injury to the inhabitants of the sub-district itself; but that part which was retained in badly-constructed sewers in Croydon, and had an opportunity given to it to change the form of its elements, produced much mischief to those who had the misfortune to live upon the lines of the badly-constructed and imperfectly ventilated sewers. My own impression is, still, that the sooner sewage is conveyed to the country, and at once utilised, the better for the town. The receipts and vital statistics now published, I think, prove that it is also no drawback to the land itself. There is one other point worth mentioning, as decreasing the value received from the farm; the great amount of water which has had to be dealt with during the past year has decreased the returns. Excessive flushing of sewer, and heavy rainfalls, much of which still passes into the Croydon sewers, have taxed the land to the uttermost. This year will see an improvement in that direction; a large part of the surface water will be abstracted from the sewers and sent into its proper channels. The market gardening, also, has been given up, in consequence of the impossibility of a local board dealing properly with such grounds."

Viewing the internal works of house and town water supply, and house and town drainage, simply as a means of preserving and removing the manures of the town for agricultural production, these points are to be considered, the equable dilution of the manure in the house for its application on the farm, and the equable dilution of the manure derivable from the streets and the roofs of houses. It is considered that in the houses there is a loss of manure from the permeation of the soil with foul or waste water, through defective drains and sewers, and also an excessive and inconvenient dilution of the surface manure, the horse-dung and other refuse on covered surfaces, by the addition of storm-water into the sewers, which, instead of being carried to the fields ought to be carried to the rivers. Dr. Carpenter states that measures are being taken to reduce the waste of the water distributed for domestic consumption, which is now as high as 40 gallons per head of the population, and by complete measures it ought to be reduced to about 11 or 12 gallons per head of the population.

The feeding of plants with liquified manure, or giving them food and water at the same time, the future of agriculture, as declared by De Candolle, is a specialty yet to be cultivated. On the inquiries made as to how it was that, with a cheap method of removing manure, and such a cheap method of applying it by water-carriage, and with the attainment of such a superior amount of produce, it, nevertheless, has not been remunerative to the population, the answers were, that in the first place the rents exacted for the use of the land were excessive; namely, that for land of the ordinary rental of twenty-three shillings per acre, £10 sterling was charged against the town. In addition to which, the first works were without befitting economy, and unduly expensive. In addition to which, the salaries and labour expenses were unnecessarily beyond the rates of ordinary agricultural expenses, and, moreover, that the produce comes at different times, and in different quantities to the ordinary agricultural produce, and that the first sales were to a disadvantage, from want of demand at the unaccustomed times. "A Local Board," he said, "labours under very great disadvantages in carrying on a business like a farm. The wages sheet alone will prove this, for there is no one whose pecuniary interest it is to keep down the expenses. Idle hands are retained, and every man's hand is against the Local Board, and in favour of the private individual; whilst the managers themselves, as soon as they become aware of the work that is before them, make violent enemies of those men whom they have prevented from fattening on the rates. But they make few active friends amongst the better part of the community, who declined to take part in local politics. The result is that, at the next election, the management is changed, and most of the advantages of former experience is lost."

Dr. Carpenter observes further, that these disadvantages would, with others, be avoidable when pointed out for a recommencement *de novo*.

There was in 1875 an epidemic visitation of typhoid fever in a part of the town. At first it was ascribed to the impurity of the water. On an analysis of the water at its sources, it was found to be exceptionally pure, but the source of impurity was in the sewer gases evolved from the putrid deposit in the defective drainage works.

The pipes for the discharge of waste water were often made to open into the sewers or the drains. On the occurrence of certain atmospheric conditions, which occasion an unusually copious evolution of the gases of putrefaction, these gases extend through the waste water-pipes of the butts or cisterns, and being there very much retained by the lids of the cisterns, are rapidly absorbed by the water. A sewer epidemic, in a prison of the highest ordinary condition of health, and recent examinations, have shown that fatal cases of fever occur more frequently from the unskilful conditions of drainage works than has hitherto been suspected.

Dr. Carpenter states that, when the recited defects are removed, and other objects are attained that come within the recognised province of public sanitary authority, such as the prevention of overcrowding, the better cleanliness and ventilation of common schools, which are the centres of children's epidemics, that, without interfering with the ordinary habits of the population in other respects, a further reduction of the death-rate in Croydon, from 17 or 18 to 14 per 1,000 may be effected.

[Dr. Carpenter now states that much of this has been effected, and that during the past 12 months only about four fatal cases of typhoid have occurred in a population of 66,000 people.]

Dr. Carpenter points very emphatically to the experiences there of the removal of excreta, by the method very popular with small landlords in town councils, and with ill-informed persons, by the tub system, which is in every way inferior, and ten times more expensive, than the system of removal by water-carriage, through self-cleansing house drains and self-cleansing sewers; and that as a mere matter of economy of transit, apart from the objection to the retention of decomposing matter about the premises. When the system of water-closets was introduced by the first General Board of Health as a measure for the entire urban populations, it was violently objected, as it is now objected to for Indian cities, as so repugnant to the habits of the as masses, sure to be misused by them, and as being impracticable. Yet in this city, as in others, it has been brought into general use by all classes, to the very lowest, without complaint or objection on the score of misuse.

The failure in the apparatus was not from its misuse, except in solitary instances, by the people; but from ignorance on the part of architects and builders, the creation of drains and sewers of deposit, and from the ignorance of the local authorities in seeing that the ratepayers' money was properly expended, and the work properly done.

A practical test of the underground work is, to have marked substances put in at the head of the works, and see whether they arrive in due time at the outfall. If they do not arrive, it shows that they are detained somewhere; and if so, that there has been failure in design for which engineer and contractor ought to be made responsible, and compelled to take up the work and complete it in a proper manner before payment is made. Bad engineering and bad work may everywhere be detected by the nose, by the escape of foul smells.

The experience of this city, it was acknowledged, exemplifies a common practical conclusion, that the internal house apparatus for carrying water into houses, and the internal house apparatus for carrying the fouled water out of the house and into the common sewers, should form part of the general system of water supply, and should be provided from a public rate, and be kept in current action, for the common security, under a public supervision, to ensure efficient and economical action in the interest of the general public.

We visited the farm, and inspected the condition of the sewage, as it was passed on to the land from the town sewers. It was then in the condition of a chocolate coloured fluid, but without the factor of advanced decomposition. After having been spread over the land and amidst the vegetation, it permeates through the stratum, and is carried by permeable agricultural drains to an outfall. The stratum of soil with the vegetation forms a great filter. When discharged at the outfall from the land, the sewage was a pellucid stream, deprived of all the fibrous or colouring matter as discharged from the town, and was stated to be purified, as tested by analysis, to an extent that rendered it legally admissible to the river. As another test of efficiency of the process of filtration through the land, it was stated that the river was now particularly well stocked with fish. On this point of river purification, no suggestion of improvement was heard. The object of recent legislation was fully attained.

Bedford.

We visited this town, which contains about 20,000 inhabitants, living in 3,500 houses, and is deemed a fair example of a town cleansed under the new system of water carriage, with a direct application of the liquified or the sewer manure to agricultural production on a farm. We were attended by Mr. George Hurst, a gentleman who is an active member of the local board, and of the Association for the Promotion of Social Science, and also by Mr. Lund, the town engineer, and by the manager of the farm.

The site of the town is on deep gravel; the houses, not unusually overcrowded, are widely spread, and it was one not the most prominently needing sanitary improvement, but the wells were beginning to be polluted by fæcal matter, when it was determined to have a new supply of water—not a river supply, but a spring supply—distributed into all the houses, and to have all the fouled water with the fæcal matter in solution distributed on an adjacent farm. And this was done. All the houses, except some detached outlying houses, are now water-closeted. All the excreta from them is now in course of instant removal from the site of the houses and of the town, and in a very short time (within an hour or two) it is upon the land. Mr. Hurst stated that the result of the work had, on the whole, been satisfactory to the town. The previous death-rate had been about 24 in a thousand annually. The last year had been a year of exceptionally high mortality, and it was 19 in a thousand, but in the previous year, it has been about 18 in a thousand, so far as could be ascertained from not very clear statistics.

Accepting what has been done as an improvement, the object of the inquiry was to ascertain what has been the shortcoming in results and in expense, and how much further the improvement might be carried if the work had to be begun *de novo*, with the advantage of past experience.

As a sanitary test point, the engineer was asked whether all the sewers were free from smell, from the smells of decomposing matter or sewer gases? He admitted that they were not entirely so.

Were they not, then, completely self-cleansing and free from deposit? Some portions were not. About one mile out of sixteen was badly laid, let water out at the joints, and occasioned deposit to be accumulated in the sewers; hence decomposition and sewer gases from them.

How as to the house drains, were they completely self-cleansing? It was admitted that the drainage work of many of the houses were very defective. They had been badly done by private builders.

[It is proper to explain, that the defects in the sewer work were defects understood to be of the predecessor of the present engineer, and neither for those nor for the defective house drains was he responsible, and therefore there was no delicacy needed in questioning him about them. Though the defective sewer work formed only one-sixteenth part of the whole system, yet to that extent it formed stagnant cesspool, giving off noxious emanations, which, together with the defects in the house drains must permeate at times, and in certain barometric conditions, the whole line of sewers, and

distribute sewer gases into the house, and through the openings into the streets. Nevertheless, it is to be borne in mind, that the whole was previously in the condition of that sixteenth part of the system.]

As to the water-closets, or the soil pans in the houses. How were they used by the poorer classes of the people? —Very well; the pans, as a rule, were kept very clean. If there were any defect or interruption in the means of cleansing or of the water supply, the housewives were very prompt and sharp-tongued in their complaints to him (the engineer) about it.

As to the supply of water for domestic consumption what quantity was distributed?—About 20 gallons per head of the population.

Twenty gallons per head of the population! One hundred gallons per diem per house for such a place as this, a quiet rural town, was not that really in excess of the actual consumption, and a waste? Yes it was, yet it would, by better supervision of the house service pipes, be probably reduced by one-fourth, or to fifteen gallons per head of the population.

The inquiry on this topic of sanitation led to the examination of the effect of the commercial value of the sewer water, as experienced at the sewer farm.

It is to be explained, that the quantity of manure fæces and urine is now taken as a constant, at two pounds and a half per head of the population daily—men, women, and children. With a view to keep the dilution equable, for transport and application as manure, the first General Board of Health endeavoured to get water-closets, which are cleansed with little amount of water; and it was found that constructions were to be obtained, which were self-cleansing, with little more than half a gallon, or five pounds of water, added to the fæces. But little regard was paid to the eventual disposal of the fæces as manure, and water-closets have been adopted which worked with three, four, or five times the quantity needed as a carrier. One requirement of the first General Board of Health was, that all the putrescible refuse of towns should be conveyed away in impermeable channels, generally of glazed pot pipes, and rain water, except from the covered surface of roads and streets, which had much manurial matter from the droppings of horses and other animals; but that the rainfall upon gardens and other uncovered surfaces, and all storm water, should be removed in separate channels; the subsoil land water by permeable agricultural pipe drains, and carried away to the river.

These requirements have, however, frequently been disregarded by the local and other insanitary engineers, and the channels were formed to remove storm water, as well as the ordinary rainfall. Being made to remove storm water, they are made of much larger size than is necessary to remove the ordinary house refuse, which, in dry weather days, is spread over a very wide surface, by which friction is increased, the flow retarded, and deposit occasioned, and stagnant putrefaction generated, to the deterioration of the manure, as well as the general health. To some extent, this appeared to have been occasioned here. The excessive dilution of the manure, by the unnecessary waste of water in the closet, and still more by ill-fitting service taps, was not so injurious as the excessive dilution of the manure by the outside rain and storm water. This excess so reduces the quality of the manure that it has in numerous instances, been declared to be in amount of the value of one halfpenny per ton when put upon the land. The position of agriculture, in relation to the internal drainage works of a town under the new system of drainage works, is denoted by an action brought against the authorities of another town for damages for non-fulfilment of a contract. The town had been newly drained, as was held forth to the plaintiff, on correct principles, and he contracted for the whole of the sewage, or liquified manurial matter from it, and took a farm and formed works for its application. But he found that the sewage received was not in the quantity or of the quality that it ought to be from a well and completely drained town; much of the town was left undrained, and, of the part drained, the work was, he alleged, badly done, by which he has sustained damage, for which he demanded compensation from the Court of Justice. But the public exposition of the case has been lost by a compromise.

There can be no doubt of the strong interest which agriculture has, concurrent with those of the town, in the immediate and complete removal of all excrementary matter, in the cheapest manner, by perfect internal drainage works, before it can enter into putrefactive decomposition. The formation of the excessively large sewers adds enormously to the expense of the internal drainage works, and, it must be added, adds to the profit of the engineers who persuade the town to undertake them. In the instance of this town there did not appear to be any flagrant excess in the cost of the works. But the error of the admission of storm water into the sewers, and the necessity of its separation in the interest of sanitation, as well as of agriculture, was admitted by the engineer. The channels for the removal of the sewage proper would, he said, be made smaller, with some reduction of expense, counterveiled by the expense of separate works for the removal of rain, of subsoil, and of storm water.

Notwithstanding all deductions, however, the agricultural produce from the liquified manure of the town, is in advance of any other. The sewage, in the instance of Croydon, was applied to a dairy farm, chiefly for the production of milk. The sewage of this 20,000 of population of Bedford is applied to 180 acres, chiefly of market garden culture, distributed as set forth in the account of the sales for 1876.

Irrigation Farm.—Bedford, 1876.

Description of Crop.	Acreage.			Average Per Acre.			Total Produce.		
	A.	R.	P.	£	s.	d.	£	s.	d.
Italian rye grass.....	30	0	0	12	8	1	372	2	6
Grass, permanent pasture..............	30	0	0	7	8	3¾	222	9	2
Wheat	10	1	0	6	11	3¾	67	6	1
Oats	12	0	0	9	14	9	116	17	0
Beans................	4	3	0	13	1	0¾	62	0	0
Mangolds	38	0	20	14	0	8¼	535	1	3
Onions..............	11	0	10	32	8	5½	358	13	9
Carrots	16	0	0	10	4	9¼	163	16	4
Potatoes............	10	0	0	11	2	2	111	1	6
Cabbage.............	6	0	0	13	8	10	80	13	0
Savoys	3	0	0	14	13	11	44	1	9
Pickling cabbage	2	2	0	10	0	11¼	25	2	4
Cauliflowers	2	0	0	18	6	6	36	13	0
Kidney beans		3	0	16	0	0	12	0	0
Celery..............		3	0	53	4	4	38	8	3
Cucumbers..........		3	0	18	13	4	14	0	0
Vegetable marrows ..		1	0	16	14	0	4	1	0
Asparagus			20	36	0	0	4	10	0
Rhubarb............			20	32	0	0	4	0	0
Currant trees, &c. ..	2	0	0	5	0	0	10	0	0
	180	1	30				2282	16	11

But it may serve for comparison to state the weights per acre of the chief crops, which have been as follows:—

	Tons per acre.
Italian rye grass per crop, sometimes cut four or five times a year	25 to 30
Potatoes	12 to 15
Carrots	24 to 30
Onions	12 to 16

There are some market garden farms in the neighbourhood of Bedford which are considered to be very good of their kind, which, in yield of produce on equivalent areas, is considered to be more than threefold the common agricultural produce, but the sewage farm approaches to a five-fold yield. There are some cottage allotments held by the wage classes on the outskirts of Bedford, which are highly manured with pigs, and other manure, and worked without stint of labour, but they by no means attain weights grown on the sewage farm. The liquefied manure culture exceeds them all in quality as well as in bulk. There is an increase of saccharine matter, in the carrot, for example, with an aroma which make it almost a new root for table. By reputation, the like characteristics make the produce of other sewage farms. On one sewerage farm the rhubarb is so superior that it is used for making a champagne, and a wine of the character of a "still hock." The garden and fruit farms, it is acknowleged, required a more refined culture than the ordinary agriculture, and so it is evident do the diverse cultures of these liquefied or sewerage manure farms.

A question has been raised as to the necessity of a chemical treatment of what is called sludge, namely, the paper, rags, and other fibrous matters discharged from the water-closets and house drains into the sewers. But here there is no difficulty in dealing with it advantageously. It is dealt with as solid manure, and worked into the land, and is found to exercise a high fertilising property for about two years. About two and a half per cent. of the space of land is found sufficient to utilise this refuse satisfactorily. But it is objected that this and others of these sewage farms are unremunerative, and truly they are very little likely to be remunerative while expensive engineering works, so much beyond the agricultural economy, are charged against them, together with the internal works of the town drainage, however extravagant. In the instance of this farm, is is contended that, inasmuch as it would be requisite to pump the sewage out of the town if it were thrown into the river as worthless, the cost of pumping, amounting to £360 a year, ought not to be charged against the land. Moreover, it is charged with an exaction of £5 an acre, or more than double the average rent of the best agricultural land in that vicinity. On a fair adjustment of the expenses, the farm is at present deemed to be remunerative. A commission of inquiry was recently held on the different modes which had been allowed to the town councils of treating town sewerage. The Commissioners of inquiry were Mr. Robert Rawlinson, C.B., the chief consulting engineer of the Local Government Board, and Mr. Clare Reed, an eminent agriculturist and Member of Parliament. They coucluded, as repeated official inquiries have done, in favour of the direct application of the sewerage to the land. It may be objected that they took too lenient a view of the cost of the engineering works, and of the defaults of the official supervision due to the ratepayers, and were otherwise apologetic for failures from want of skill. They state that "the successful management of animals, and the proper cultivation of crops, require a fair amount of intelligence and experience, but successfully to carry out all the details of these matters upon a sewage farm, where there is so little to guide the practical farmer, and so much to confound his past experience and upset his previous calculations, is indeed, a hard task. And, as most sewage farms are at present under the control of ever-changing town councils and members of local Boards, whose members must as a rule be ignorant of practical agriculture, and whose theories upon the subject may be wild and visionary, is it surprising that such poor returns have hitherto resulted from the application of town sewage to the growth of crops? Disappointment has, therefore, been expressed at the very poor financial results of sewage farms. Agriculture is never a specially lucrative business, and during the last few years it is probable that strictly accurate accounts would prove that very little profit has been derived from the ordinary cultivation of arable land. Farms to which town sewage is applied have invariably many unfavourable circumstances to contend with. The rent, except where the local authority has land of its own, is certain to be extravagant; the application of the sewage is often too costly; the management is frequently changeable and faulty, and the prejudice against the produce of the farm is, in some districts, obstinate and widespread. But, where a fair rent is charged on suitable land, where the sewage is cheaply and regularly delivered, and a good market is close at hand, there is no reason to doubt that the return for capital judiciously expended upon sewage farms will produce a higher rate of interest than the money invested by the majority of the village farmers throughout the country."

Exception is to be taken to the assumption countenanced in this conclusion, that the work of sewage-farming is the work of the general agriculturists, whereas, as stated, the work of very special horticulturists.

The quantity of land needed to utilise sewage varies considerably with the soil and the culture. But it may be stated, as an approximation, that an acre will suffice to utilise the sewage of 100 of population, or a hectare for every 200 of population.

The modes of distributing the manure on the surface differ considerably, and, for practical application, it would be worth while to have comparisons made, with working drawings of leading instances, by a competent engineering draughtsman.

So also as to the sizes of house drains and sewers, on the close adaptation of which to the service for which they are required, so much of sanitary efficiency and economy depend, the formulæ in engineering works require the correction of further observation. One practical conclusion, from the experience of grievously defective works, is that attention should be recalled to original suggestions that the contractors, or the subcontractors, should be bound to maintain them in complete working order for a year or a term, and to relay immediately any drains or sewers which occasion deposit, and emit noxious smells. So, also, that works should undergo a strict official examination to ensure the exact performance of the contract, and that the works are of a nature to ensure, and be of benefit equivalent to the charge.

In respect to the cost of the internal works of water distribution, the engineer here was of opinion, with that given at Croydon, that the increase of the price of labour, and the reduction of the prices of materials, rendered it difficult to give more than wide approprximations; but that for works began *de novo* they might be taken to be, as a public service:—

	Per Week.
For bringing a constant supply of water to the door of every house	1d.
For taking into the house	1
For removing the fouled water from every house	1
For the service of the water-closet	$0\frac{1}{2}$
Total	$3\frac{1}{2}$

or a little above that rate of charge.

The lowest estimated supply here is 15 gallons per head of the population, or for a household of five, more than 500 gallons of liquid, carrying upwards of 100 weight of excreta per week. No human labour, not the cheapest labour of the Hindoo cities, can compete in cheapness with water-carriage.

To this economy, however, is to be added the economy of human life, and the saving of the loss of productive force from excessive sickness. With all the shortcomings of the sanitary works, the daily immediate removal by the present system of 3,125 tons of sewage, including the rainfall, with putrescible matter, from within the town, may be credited with the reduction of

the death-rate from 24 to 18 per 1,000, or 6 per 1,000, or 120 deaths annually; and for every preventible death some twenty cases of preventible sickness are estimated. In whatsoever way the pecuniary economies of this class were estimated, it was found greatly to exceed the outlay on the new works, even if no return had been derived from the increased agricultural production.

Preliminary inquiries have been made as to other towns, fraught with indications of important results for future guidance as to central and local administration, as well as to works.

WORKS OF SEWERAGE AND SEWAGE DISPOSAL.—CROYDON RURAL SANITARY AUTHORITY.

By Baldwin Latham, C.E., M.Inst.C.E., F.G.S., F.M.S., &c.

For some years past the Croydon Rural Sanitary Authority have had forcibly brought to their attention the necessity for a complete system of sewerage and sewage disposal for Beddington, Merton, Merton Rush, Mitcham, Morden, and Wallington, being parishes or places under their jurisdiction for sanitary purposes.

The aggregate area comprised within these districts is 10,106 acres, or nearly sixteen square miles. The population at the present time is about 16,000, but it is very rapidly increasing, and since 1851 has more than doubled. Several centres of population are located in the drainage area, but at considerable distances apart.

Geologically, the district embraces the various formations found in the neighbourhood of London, and lying over the chalk, which is the lowest geological formation in this district, and finishing with an alluvium overlying the London clay.

Naturally, the district drains to the Beverley Brook and the River Wandle, both of which streams flow in a northerly direction, and ultimately fall into the River Thames within the metropolis. The natural falls of the district are towards the metropolis, and as the district in question is contiguous thereto, it was a matter of some difficulty to provide an economical and sufficient scheme for effectually treating the sewage when a system of sewerage came to be carried out. It was considered that the cost in lifting the sewage, and carrying it a considerable distance in such a district, was quite out of the question, but ultimately a scheme was adopted, and is now in course of rapid execution, by which sixth-sevenths of the whole of the sewage of the combined districts will be conveyed by direct gravitation to land located partly in the parish of Wimbledon, outside the jurisdiction of the Croydon Rural Sanitary Authority, and partly in the parish of Mitcham, within the jurisdiction of the Rural Sanitary Authority.

An area of 38 acres of land has been purchased, by agreement, for which a sum of £11,700 was paid. Thirty acres of this land is an alluvial deposit, principally gravel, through the centre of which formerly ran the old channel of the river Wandle, the remaining eight acres being stiff brick earth. In order to convey the sewage of the district to the proposed area, 36 miles of sewers are required to be constructed. Of these 36 miles of sewers, $29\frac{1}{4}$ miles are ordinary socket pipes, jointed with tarred gasket and Portland cement, varying in size from nine inches to 18 inches in diameter, and five miles of earthenware pipes with Stanford's patent joint. The latter also vary in size from nine inches to 18 inches in diameter. There will also be $1\frac{3}{4}$ miles of brick sewers, 24 inches, 27 inches, and four feet in diameter. The four feet sewer is to be used as a tank sewer in connection with that portion of the district, the sewage of which will not flow by direct gravitation on to the land, and it is made of the size in question in order to hold the sewage during the night, or at any period when the engines may require to be stopped. The sewage of one-seventh of the whole district, will require to be pumped to a height of 25 feet, including friction. It will then pass with the sewage from the gravitation area through a series of tanks, in which the solids will be deposited, and the liquid will then flow on to the area of land laid out for filtration. The land which is now being prepared for filtration is an alluvial bed 30 acres in extent, but as this land is entirely surrounded by rivers and streams, and is extremely porous, in order to fit it for sewage purposes, it was deemed advisable to form all round it a puddle wall, which is carried through the alluvial bed of gravel and porous soil into the London clay lying below, and thus shut out the adjoining waters, which have hitherto percolated into the land, and made it a swamp. A main arterial drain is carried through the centre of the land, and subsidiary drains will be made, by which the whole area within the puddle walls will be made the freest possible filter for purifying the sewage which is to be brought upon it.

The tanks for freeing the sewage from the solids are so arranged that chemicals may be used for producing precipitation before the application of the sewage to the land. It is not, however, contemplated to use chemicals directly to the sewage. Owing to the position of the works with reference to the contiguous population, and having regard to the desirability of preventing the slightest nuisance, the tanks for treating the sewage are placed under cover, and the solids or sludge, which will be removed by subsidence from the sewage, will at once be consolidated. For this purpose the sludge will be received in a lower tank than the filter tanks, where it will be treated with lime, so as to destroy its adhesive properties, and then be forced through filter presses, so as to consolidate it ready for immediate removal.

Experiments have been made with reference to the purifying properties of the area selected for filtration. Some portions of the soil of this area, in its natural state, are not so efficient as might be desired, when compared with other lands well known to be suitable for the filtration of sewage. There is no better way of testing land as to its fitness for sewage filtration than by ascertaining the per-centage of water, by weight, it is capable of temporarily holding without loss. The most unfit parts of the area at Mitcham have been tested with the following results:—

			Per cent. of water absorbed.
No. 1	Sample,	Yellow clay........	53·3
,, 2	,,	Loam, sandy	50·2
,, 3	,,	Peat..............	120·0
,, 4	,,	Loam..............	62·0
,, 5	,,	Loamy soil........	60·0

If the above samples are compared with the

characteristics of well-known lands adapted for the purification of sewage, it will be seen that they are greatly inferior to some of the following:—

	Per cent. of water absorbed.
Surface soil of the Merthyr filters at Troedyrhiw	39·82
Subsoil ,, ,,	45·77
Another sample of subsoil	37·48
Additional land at Merthyr for the reception of the sewage of Aberdare—surface	49·05
Ditto, immediately below surface	41·35
Ditto, subsoil	13·07
Beddington sewage farm—surface	50·0
Norwood sewage farm—surface	59·0
Ditto, subsoil	41·0
Dursley soil (well known for its purifying powers)	34·0
Chorlton Ees, near Manchester—surface	56·71
Same soil after being burnt into ballast	36·55

The porosity of soil, or the power to allow water to pass by filtration, is inversely in proportion to its capacity for retaining water. With rocks, however, it is the reverse, the smaller the per-centage of water rocks will contain, the more dense and impenetrable they are to water. Clay soils, when burnt into ballast, differ in their physical properties very little from the Dursley soil, which was experimented upon by the Rivers Pollution Commissioners with such satisfactory results, and the experience of late years has shown that this material, when used as a filter, is well adapted for the purpose of purifying sewage, and so in districts where clay soil only is to be found, this material may be made into artificial filters, which will have a greater purifying power than is the case with almost any natural soil, perhaps with the exception of Dursley soil, which, in its colour and characteristics, is not unlike burnt clay.

The eight acres of clay land that have been acquired by the Croydon Rural Sanitary Authority, when made into artificial filters, can be made to effectually purify the sewage of about twenty thousand people. The unfavourable position which peat occupies in reference to its retention of water is confirmatory of the experiments of the Rivers Pollution Commissioners, who showed that it was about the worst material that could be selected for a filter, and in the case of the Croydon Rural Sanitary Authority's works, will require to be entirely removed, and a more efficient material substituted.

The total cost of the Croydon Rural Sanitary Authority's works is estimated at £96,000. This amount, however, will no doubt be exceeded, as there are many new streets now being formed in the district, all of which it will be necessary to sewer. The cost to the present ratepayers of the district will be entirely covered by a rate of 15d. in the £, which includes the working expenses and the repayment of the principal and interest. No allowance is made for any returns from the land to which the sewage will be applied, and the rate includes the interest and repayment of the principal for the purchase of the land. There will, however, be a considerable return from the land, which cannot, in this neighbourhood, so near to the metropolis, be put down under from £15 to £20 per acre as the value of the crops, which would not be all profit, as the cost of cultivation must be deducted; but even if the cost of cultivation equalled the value of the crops, it is true economy to utilise the sewage, when compared with the system adopted in the metropolis, and now extending to other places adjacent, of removing the nuisance from one spot to another lower down the same river. As the district of the Croydon Rural Sanitary Authority is fast increasing, both in population and rateable value, there is every reasonable probability of the rate being lessened. If the cost of these works is compared with the cost which has been incurred in adjoining districts, in which the sewage is disposed of by being collected into arterial drains, and then thrown into the Thames, it will be seen that the whole system of sewerage, with its works for purifying the sewage, will cost the ratepayers of the district but a tithe of the amount the ratepayers of adjoining districts have to pay for simply constructing the outfall sewer only. This is a strong example of the economy of locally treating and purifying sewage, rather than shifting a nuisance, at great cost, from one point to another, from which some day it will have to be removed at still greater cost.

MISCELLANEOUS.

POSTMASTER-GENERAL'S REPORT.

The 25th annual report of the Postmaster-General, for the financial year ended the 31st of March, 1879, lately presented to Parliament, shows a satisfactory rate of progress in most branches of post-office work. The number of new post-offices established during the year was 258, raising the total number of offices open in the United Kingdom on the 31st of January last to 13,881. Inclusive of road and railway letter-boxes, the accommodation now provided throughout the United Kingdom for the deposit of correspondence in the post is represented by no less than 25,767 receptacles. In 1840, the year of the introduction of penny postage, there were only 4,028 places of deposit, the number of postal receptacles in London alone being now 1,981. A new building, which is rapidly approaching completion, is being constructed in Queen Victoria-street, for a central savings bank. Owing to the vast growth of London it has been found necessary to diminish, for the purpose of supervision and control, the area which has hitherto been comprised in the western, south-western, and south-eastern postal districts. Thus the western suburbs are now under the control of the Paddington office, and Putney, Wimbledon, and Norwood have each a head-postmaster. The outer suburbs of London and many additional provincial towns have now a late or early morning collection of letters for the first delivery in London, and for the principal morning mails to the provinces. The scale of fees for late posting in London has been greatly reduced, and special letter-boxes for late posting of Continental letters, &c., have been put up at Charing-cross, Cannon-street, and London-bridge. The system under which senders of ordinary letters could obtain, upon application, certificates of the posting of such letters, has now been abandoned.

The number of letters delivered in the United Kingdom during the year 1878-9 was greater than the number delivered during the preceding year by 39,640,500, or an increase of 3·7 per cent.; the number of post-cards has increased by 9,208,400, or 9 per cent.; the

number of newspapers is greater by 2,337,300, or 1·8 per cent.; and the correspondence of all kinds together dealt with during 1878-79 shows an increase of 58,062,100 on 1877-78, being at the rate of very nearly 4 per cent., and an average of 45 per cent. per head of the population. The weekly number of letters posted in the London postal district during 1878 was 7,150,000, and the number delivered 7,145,000. In the East Central district, which is confined almost wholly to the City proper, about 1,008,000 letters are delivered at the first or morning delivery every day; about one million letters a-week are posted at the General Post-office; more than half a-million at the branch office in Lombard-street; nearly as many at the branch office in Mark-lane; and about 200,000 a-week at the Ludgate-circus office. The letters delivered in the London district form rather more than one-fourth of all the letters delivered in the United Kingdom. They are more than twice as numerous as the letters delivered in Scotland, and above three times as numerous as the letters delivered in Ireland.

The reduction of the registration fee has largely increased the number of registered letters. Seven million two hundred thousand three hundred and fifty letters were registered in the United Kingdom in 1878, as against 4,316,047 in 1877. Nothing, however, seems to prevent a portion of the public from attempting to evade the registration fee, and some curious instances are quoted, such as where a £20 Bank of England note has been pinned to the leaf of a book, or several £5 notes have been enclosed in a halfpenny wrapper. No less than 38,311 undelivered letters, on being opened for the purpose of returning them to the senders, were found to contain money and valuables easily convertible into money; and a letter, the contents of which were stated to be worth £125,000, and which was intended to be registered, was found among the ordinary correspondence. The parcels of Christmas presents which passed through the Registered Letter branch of the London office exceeded 30,000 in number and three tons in weight, and the officers of this branch were continuously occupied from 3.45 a.m. on the 24th of December until noon on the 25th in disposing of this unprecedented amount of extra work.

The Postal Union Congress, which met at Paris in May, 1878, determined on no material modifications in the principles of the original treaty of 1874, but altered many of its details, the most important change being a reduction of the payment for land and sea transit of mails, which, while involving a considerable sacrifice of postal revenue, has resulted in a gain to the public by reducing the postage rate charged to distant countries. The rate on a letter to India or China has, for instance, been lowered from 6d. to 4d., and that upon books and patterns from 2d. to 1d. for each weight of 2 oz. The British colonies of Canada, Newfoundland, British Honduras, Gold Coast, Gambia, Lagos, Sierra Leone, and the Falkland Islands have become members of the Postal Union, which has also been joined by Mexico, Salvador, Liberia, and the Honduras Republic. The arrangements for providing postal facilities for Cyprus, both as regards its internal correspondence and communication with this country, are described as satisfactory.

The number of letters, &c., forwarded to and received from European countries and Egypt during 1878 was 34,400,415 and 28,683,762 respectively, or an excess of exports over imports of 5,716,654. During the four years that the Postal Treaty has been in force the yearly rate of increase in letters received has been 11·6, 9·8, and 15 per cent.; and in letters, &c., despatched 11·5, 16·1, and 13·7 per cent.; 205,664 newspapers addressed to foreign countries were detained for insufficient postage or for infringement of the regulations, or 17,268 more than during the preceding year.

As regards the Telegraph Department, notwithstanding the depression in trade, there is an increase in the number of messages over the preceding year, though only to the extent of 317,617. The total number of messages forwarded was 24,459,613, and of delivered 22,792,000. Nearly 286 millions of words of news were delivered in the course of the year to newspapers, clubs, &c. The total number of telegraph offices open on the 1st of March was 3,853, in addition to 1,401 railway stations. Several improvements have been introduced in the apparatus, one by means of which a wire is made capable of simultaneously conveying four streams of messages—two in each direction—has added another to the fast speed instruments in use by the department.

The process of superseding overhouse by underground process in London and other large towns is being continued, and the private wire business—more affected than any other by the state of trade—shows a satisfactory increase.

Notwithstanding that the total money-order business for the past year shows a considerable decrease, both in the number and amount of the orders issued, yet the transactions result in a profit to the department of £39,027, against £6,420 on the transactions of the preceding year. The inland transactions show a decrease of 5·3 per cent. in number, and 7 per cent. in amount on those for 1877-78. This decrease is attributable to many causes, among which are the depression in trade, the increase in the rate of commission, and the reduction of the registration fee. The discontinuance of the use of money orders for the payment of the salaries of National school teachers in Ireland must also be taken into account.

The number of money-order transactions with the colonies was 184,819, of the aggregate value of £711,816, being an increase of 9,070 and of £32,445 respectively on the figures for the preceding year.

The money-order transactions with foreign countries again show a good increase in both directions, the number exchanged being 265,039, of the aggregate value of £679,354, as compared with 226,326, of the aggregate value of £603,964, in 1877.

The Post-office employed 45,947 persons, of whom 11,448 were employed exclusively on telegraph work, the staff in London alone being 10,743.

An extract from a statement furnished by the Controller of the Savings Banks closes the Postmaster-General's report, from which it appears that the number of withdrawals and deposits effected in 1878 were larger than in any previous year, being 3,360,636 and 1,304,617 respectively. Since the establishment of the post-office savings banks 5,783,527 accounts have been opened and 3,890,771 closed. In round figures, and inclusive of interest credited to depositors, the total amount deposited from the commencement was £111,012,000, and the amount withdrawn £80,601,000, leaving a balance remaining as deposit on the 31st of December, 1878, of £30,411,000.

THE EDDYSTONE LIGHTHOUSE.

The construction of the new lighthouse will present several important differences from that of the one which it is intended to supersede, and the *Times* says that Mr. Douglass, the Engineer-in-Chief to the Trinity House, has arrived at the conclusion that the shape of the tower tapering upwards in a curve from its foundation was not the best that could be designed. By allowing the waves to run up readily towards the summit, this shape had the effect of throwing the main stress of the water upon the upper part of the tower, where it acted with enormous leverage to weaken the base. The wave strokes thus delivered against the old building not only produced great tremor of the entire structure, but drove the water through the weakened joints of the masonry. The upper part has been supported on two occasions, in

1839, and again in 1865, by strong internal wrought iron ties, extending from the lantern floor downwards to the lower portion of the tower. In order to diminish the effect of these upward strokes, and to give increased strength to the foundation, Mr. Douglass determined to place the curved portion of the tower upon a base with vertical sides, which would not have the same tendency to produce an upward run of the waves; and also to lay the foundations in a somewhat different manner.

The old lighthouse was built upon a portion of the reef which, in ordinary weather, is just at the level of high water, and which affords no more than room for the structure placed upon it; but the new one will stand upon a portion which is entirely submerged at high water, and which is the summit of a sort of platform of rock, slightly convex in its general form, aud thus having a somewhat broad base at a level lower than its central part. In this central part an excavation has beeu made to receive the foundation; and the floor of this excavation is 2 ft. 6 in. below the low-water mark at spring tides. The tower will contain nine apartments, each 10 ft. in height, in addition to the lantern, the seveu uppermost being 14 ft. in diameter. The elevatiou of the light will be 130 ft. above high water, instead of 72 ft., as at present, by which its range will be increased from 14 to about 17½ nautical miles, so that it will just overlap the range of the new electrical lights at the Lizard. The preeise kind of light and the precise kind of fog-signal which will be employed have not yet been determined upon.

The method of carrying on the works is interesting. It is conducted by means of the twin-screw steamer *Hercules*, which was built expressly for the Great and Little Bass lighthouses at Ceylon, and which carries all the necessary appliances, besides serving as a barrack for the meu. The steamer leaves Plymouth every day in time to arrive at the Eddystone reef soon after the beginning of ebb tide; and the first thing done is to guide her by warps to her resting-place, where she is finally made fast by hawsers to buoys and iron stanchions fixed in the adjacent rocks. When thus moored, her stern is only a few boats' lengths distant from the scene of operations. A party of men land upon the reef and rig up the eraue, while others bring hose from the steamer, by which one or more of the compartments of the coffer-dam can be pumped dry as soou as the waves eease to break over and refill them. By meaus of a smaller hose, compressed air is driven from the steamer to work the rock drills which are used iu exeavating, Mr. Douglas having decided not to employ any kind of blasting process, lest it might diminish the stability of the foundation. On the deck of the steamer there is a railway, on which a truck conveys heavy loads, such as blocks of granite, bags of bricks or of sand, and barrels of cement, to the steru, whence they are carried to the rock by means of a double chain, extending from a strong timber framework on board to the crane in the central platform, and worked over the pulleys by the eugiues of the steamer. By the aid of these appliances the work goes on rapidly, the rock is cut away, the excavated surfaee is levelled and prepared, and the massive blocks of granite are brought one after another into positions which they will occupy, as far as humau foresight cau predict, as long as the reef itself remains. After about three hours of work the rising tide begins to give notice that the time has come to prepare for departure. Everything which is loose is retuined to the steamer, the arm of the crane is lowered and lashed to some of the fixed stanchions, and the last of the meu are leaving just as the waves are beginniug to break over the spot on which the future lighthouse is to be reared.

The granite of which the lighthouse is being built is itself worth of notice. The blocks of the cylindrieal base are each 6 ft. 6 in. deep, 2 ft. thick, and 3 ft. 10 in. on the outer eireumference, and they are all without a flaw. They are of a kind much resembling the Dalbeattie stone, and hardly to be distinguished from it at a little distance; but they are yielded by the De Lank quarries, near Bodmin, which have only lately been brought iuto full operation, and which promises to afford a practieally inexhaustible supply of blocks of a magnitude not to be approached elsewhere.

PETROLEUM FROM THE CASPIAN.

A correspondent of the *Daily News*, writing from Baku, on the Caspian, gives an account of the petroleum springs existing there. All around Baku the ground is sodden with natural issues of naphtha. In some places the earth is eonverted into a natural asphalte, hard during cold weather, but into whieh the foots sinks a eouple of inches at midday. Add to this that, owing to the scarcity of water, the streets are moistened with coarse black residual naphtha. It effectually lays the dust during 15 days. After this period a thick brown dust lies four or five inches deep in the roadway, over which the numerous "phaetons," or street carriages, glide so softly and noiselessly that the foot passenger is frequeutly in danger of being run over. When a north or west wind arises, the air is thick with impalpable marly earth, combined with bitumen. The least glow of sunshine fixes this indelibly in one's clothes. No amount of brushing or washing ean remove it.

The shores of Baku bay north of the town trend towards the east, and some five or six miles distant are the petroleum, or, as they are termed, the naphtha springs. The surroundiug district is almost entirely destitute of vegetation; and in its midst are some black-looking brick buildings, interspersed with eurious wooden structures, twenty feet high, resembling Continental windmills. These latter are the pump or well-houses covering the borings for oil, and in which the crude liquid is brought to the surface. All around smells of petroleum, and the ground is black with waste liquid and natural infiltrations. Boring for naphtha is conducted much in the same manner as that for coal. Au iron bit, gouge-shaped, is fitted to a boring bar, eight or ten feet in leugth, which is successively fitted to other lengths as the depth of the piercing iucreases. This depth varies from fifty to one hundred and fifty yards, this difference existing even at very short horizontal distanees, sometimes not over forty yards. Layers of sand and rock have to be pierced. It is in the sand that often the greatest difficulties have been met with. A loose boulder will meet the boring tool, and displacing itself leave the passage free. But when the rods are withdrawn to allow the introduction of the tubes which form the lining of the well, the boulder falls back to its place, and baffles all attempts to continue the orifice. This boulder difficulty is the great terror of those commencing to bore. Sometimes, after a lengthened discharge of heavy carburetted hydrogeu, the naphtha rises to the surface, and even flows over abundantly, as in the case of the artesian well. Under ordinary circumstauees, it has to be fished up from a considerable depth. The boring is generally ten, or at most eighteeu inches, in diameter. A long bucket, or rather a tube stopped at the bottom and fifteeu feet in length is lowered into the well, aud drawn up full of crude petroleum, fifty gallons at a time. This, which is a blue-pink transparent liquid, is poured iuto a rudely constructed, plank-lined trough at the door of the well-house, whence it flows by au equally rude ehannel to the distillery. The distillation is conducted at a temperature commencing with 140 degrees Ceutigrade, much lower, I am told, than the first boiling point for that from Pennsylvania. When uo more oil eomes over at this heat, the result is withdrawn aud the tem-

perature increased by ten degrees. This second result is also laid aside, and the heat being again increased a third distillation is carried on until no further easily evaporated liquid remains. This last is the best quantity of petroleum for lamps. That which preceded it is the second quality; and the first, or highly volatile, liquid is either thrown away or mixed with the best and second best as an adulteration. The thick dark brown treacly fluid remaining after distillation is termed astalki, and is that used for the irrigatiou of the streets. The distilled petroleum, if used in lamps, would quickly clog the wick with a carbonaceous deposit. Previous to being offered for sale, it is placed in a large reservoir, within which revolves a large paddle-wheel. Sulphuric acid is first added, and after being allowed to settle, the clear top liquor is drawn off, and similarly treated with caustic potash. After this it is ready for sale. Up to the present, the residues, after the acid and potash treatments, have not been utilised. I have uo doubt but that later on, valuable products can be derived from them. With the astalki, or remuant after the first distillation, it is different. For years past it has been the only fuel used on board the war ships and mercantile steamers of the Caspian. At Baku its price is only nominal, vast quantities being poured into the sea for lack of stowing space or demaud. In cooking apparatus it is used, and for the production of gas for lighting purposes. In the latter case it is allowed to trickle slowly into retorts raised to a dull red heat, pure gas with little graphite being the result. Weight for weight this waste product gives four times as great a volume of gas as ordinary coal. By distillation at a high temperature aud treatment with an alkaline substance, a product is obtained which is used as a substitute for oil in greasing machinery.

Apart from the local use of petroleum for lighting purposes, aud its exportation for a similar use, comes its application to steam navigation. With the old-fashioned boilers in use, having a central opening running longitudinally, no modification is necessary for the application of the new fuel. A reservoir, containing some hundred pounds weight of the refuse (astalki), is furnished with a small tube, bearing another at its extremity, a few inches long, and at right angles with the conduit. From this latter it trickles slowly. Close by is the mouth of another tube, connected with the boiler. A pan containing tow or wood saturated with astalki is first introduced to heat the water, and once the slightest steam pressure is produced, a jet of vapour is thrown upon the dropping bituminous fluid, which is thus converted into spray. A light is applied, and then a roaring deluge of fire iuundates the central opening of the boiler. It is a kind of self-acting blow-pipe. This volume of fire can be controlled by one man by means of the two stop-cocks as easily as the flame in an ordinary gas jet. This I have repeatedly witnessed on board the Caspian steamers. As regards the expense, I give the following data on the authority of a merchant captain who has used uaphtha fuel for years. His steamer is of four huudred and fifty tons, and of one hundred and twenty-horse power. He burns thirty poods per hour of astalki to obtaiu a speed of thirteen nautical miles in the same time. One pood is about thirty-three English pounds (16 kilogrammes), and costs on an average from five to six pence. Thus a twenty hours' voyage at full speed for such a vessel costs about twelve pounds sterling. The fuel is as safe and occupies much less space thau the amount of coal necessary to produce a similar effect, not to speak of the enormous difference in price, and the saving of manual labour. Two engineers and two stokers suffice for a steamer of a thousand tous burden. With the immense supply of natural petroleum, as yet only very slightly developed, and its application to the already guaranteed railway from Tiflis to Baku, and to the inevitable future ones beyond the Caspian over the plains of the far East, I think this subject is worthy of every attention. Yet there are proprietors of large tracts of petroleum-bearing ground whose capital rests unproductive because of a want of demand. The island of Tchilican, not far from Krasnavodsk, teems with the precious liquid. The seaward cliffs are black with its streams flowing idly into the sea; and a natural paraffin, or "mineral wax," is found abundantly in the island and in the low hills a hundred versts west of Krasnavodsk. All round Baku the ground is full of naphtha. In hundreds of places it exhales from the ground and burns freely when a light is applied. Only a couple of months ago the volatile products produced a remarkable effect a couple of miles south of Baku. A large earth cliff fronting the sea was tumbled over as by au earthquake shock, and, as I saw myself, hugh boulders and weighty ships' boilers were thrown a hundred yards. In some places I have seen fifty or sixty furnaces for burning lime, the flame used being solely that of the carburetted hydrogen issuing naturally from fissures in the earth.

THE ELECTRIC LIGHT.

The result of some experiments on the relative economy and illuminating power of gaslight and the electric light, which were lately tried in the Picton reading-room, a large round building with dome, just completed, between the Brown Library and Museum and the Walker Art Gallery in Liverpool, is reported in the *Times*. Both the Liverpool Gas Company and the British Electric Light Company were afforded facilities for illustrating the illuminating power of their respective ageucies. The Gas Company had erected an exteusive temporary arrangement with the object of flooding the the large apartment with a bright and steady light, and it is estimated that in their efforts to accomplish this end, the gas was consumed at the rate of 2,000 cubic feet an hour, or a cost of 7s. an hour. The method of illuminating by the electric light, originally proposed by the engineer of the British Electric Light Company, was by reflection, chiefly from the dome, and the arrangement of placing the light ou a centre pedestal (which is the borough engineer's idea), most effectually carried out this method. The electricity was generated from the Gramme machines, driven by the engine which supplies the Steble fountain, but which is not suited for the electric light purposes, and is blamed for the unsteadiness still noticeable. It is said that the cost of the electric light was about one-third of the price of the gas illuminatiou, and the Library and Art Committee consequently determined upon adopting it.

OBITUARY.

Sir Rowland Hill, K.C.B.—After an illness that caused his death to be daily expected, Sir Rowland Hill passed away on the morning of Wednesday, the 27th inst., at the ripe age of eighty-three years. His early life was spent in the practical application of uew views of school discipline, aud at the age of eleven he begau to assist his father (a schoolmaster at Birmingham) in teaching; his own school education terminating at 12. After remaining as oue of the managers of the school at Hazelwood, near Birmingham, until he was over 30, he established, with the aid of one of his brothers, a brauch school at Bruce-castle, Tottenham. He was subsequently among the founders of the Society for the Diffusiou of Useful Knowledge, and he became, iu 1835, secretary to Gibbou Wakefield's Association for the Colonisation of South Australia. In 1837, he struck the first blow against the old system of the Post-office in a pamphlet which attracted public attention,

and after great difficulties had been overcome, he finally triumphed, when on January 10th, 1841, the penny postage came into effect. At this time there were only 4,000 post-offices in the United Kingdom. Now, as will be seen in another page, there are over 25,000 post-offices and places of deposit for letters. During the few years that he was away from the Post-office he was director, and afterwards chairman of the London and Brighton Railway Company. In 1854, he was appointed chief secretary to the Post-office, which office he resigned in 1864. In 1857 he was elected a Fellow of the Royal Society, and 1860 he was created a Knight Commander of the Bath. In 1864 he became a member of the Society of Arts, and in the same year he was awarded the first Albert Gold Medal in recognition of his great services to arts, manufactures, and commerce in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefits of which have extended over the civilised world. The medal was presented to Sir Rowland Hill by H.R.H. the Prince of Wales, President of the Society, at a meeting held at Willis's Rooms. When a deputation from the Society of Arts waited upon the Marquis of Hartington, in 1870, for the purpose of urging a reduction in the rates of book postage, Sir Rowland Hill wrote a letter to the *Journal* on the subject.

GENERAL NOTES.

Fisheries of Poti.—Vice-Consul Gardner states that no established trade exists in Poti beyond the incidental one of fishing. A considerable number of Skopetz (Eunuchs) obtain their livelihood by fishing for sturgeon at the mouth of the River Rhion during the spring and summer months. The process is simple in the extreme, yet difficult to describe and hard to believe. A strong line, or lanyard, about 160 feet in length, with short lines attached at a distance of six feet apart, and having a large hook at the end, very sharp but barbless; a small gourd is fastened to the back of each hook to keep it floating point downwards; these lines, hooks, and gourds are neatly arranged on the gunwale of a dugont or boat made from a single log, and run out quickly across the river, and are visited morning and evening. If a sturgeon in its passage down to the sea is pricked ever so slightly by one of the hooks it remains stationary, without struggling or making an attempt to escape. The fisherman on reaching his lines carefully overhauls them, and on finding a fish strikes it with his gaff, passes a rope through its gills, and tows it behind his dugont to the shore. If the fish is not mortally wounded, it is fastened to a post on the river side, opposite the fisherman's cottage, where it remains alive until a purchaser arrives. These fish vary in weight, from 36 lbs. to 216 lbs., realising 6d. per lb.; the caviare obtained from the female selling at 2s. per lb. Grey mullet are caught in considerable quantities by floating mats made of reeds, 50 feet long by five to six broad, on the surface of the sea in bright fine weather. When the mullet in swimming reach the shade occasioned by the mat, they jump out of the water, fall on the mats, and are taken by the fisherman waiting in his boat to receive them. Porpoise are plentiful, and are caught in strong trammels, or shot by expert marksman. A fish yields on the average 36 lbs. of oil; the flesh is not eaten. Porpoise oil sells at 2d. per lb. This business, and that of grebe shooting, is pursued by the Turks, who have about fifty small boats engaged in the trade.

Drying Machine.—A machine, which is constructed to evaporate two tons of moisture per hour, has just been brought out by Mr. A. Kelly, of Mark-lane. It consists of a horse-shoe furnace, constructed of seven tiers of cast iron pipes ranging from $4\frac{1}{4}$ inches to 6 inches in diameter, and so arranged at their base that any liquid or vapour passing through them cannot go in a direct line, but must cross and re-cross the centre of the furnace in order to be broken up and distributed as much as possible. The waste steam from an engine, or direct steam from a boiler, is introduced into this furnace, in which it rapidly becomes superheated to 1,200 or 1,500 degrees Fahr. It then passes out into a kind of surface condenser, three feet in diameter and six feet in length, containing 1,159 brass tubes six feet in length by half-inch in diameter. Here the condensation of the steam takes place, its latent heat having been imparted to a current of air forced through the tubes, by means of a "blower," into a reservoir about 16 feet in length by two feet in width; from this reservoir, and at right angles on either hand, protrude 21 five-inch perforated pipes, about four feet in length, and gathered together at their extreme ends into two smaller reservoirs, which are supposed to have the advantage of equalising the pressure of hot air in the pipes. Immediately over these pipes, forming a table of 16 feet by 12 feet, a wire netting is placed to receive the substance requiring to be dried. The steam being turned on, and the "blower" started, the air rapidly rises in temperature to about a mean of 600 degrees Fahr. Oats and straw, stable bedding soaked in water, placed upon the wire nettings, together with wet hops and brewer's grains, have been perfectly dried in the course of five or ten minutes, the hops blowing about, and the straw bedding being, not only dry, but dusty. It is expected that the machine will be useful in the drying of damaged cargoes of wet cotton, jute, &c., and waste chemical products.

The American Isthmus Canal.—M. Ferdinand de Lesseps has issued the prospectus of his new scheme for piercing the American isthmus. The company to be organised for this purpose is to be called the "Inter-Oceanic Canal Universal Company," and its capital is to be 400,000,000 f., or £16,000,000 nominal. This capital is to be divided into 800,000 shares of 500 f. or £20 each, and 790,000 of these will be offered to the public, 10,000 being reserved for the original concessionaires in payment of concessions and surveys transferred by them to M. de Lesseps. Only 125 f. per share will be called upon in the first instance, the balance being taken as required, and interest at the rate of 5 per cent. will be paid on the actual money received during the course of the construction. Subscriptions will be opened in Europe and America. In his memorandum prefixed to the prospectus M. de Lesseps estimates an income of 90,000,000 f. from the canal when it is completed, and as 85 per cent. of the profits are assigned to the shareholders he reckons that they will get 47,000,000 f. per annum, or $11\frac{1}{2}$ per cent.

Production of Steel.—In a recent number of the *Pall Mall Gazette* attention was drawn to the fact that, though England holds her own against other countries in the production of iron, the same cannot be said with regard to the production of steel, which is being enlarged at a more rapid rate in America than in England. It was pointed out that in the latter country the production of Bessemer steel ingots was eighteen times as great last year as it was in 1870, having risen from 40,000 tons in that year to 730,000 in 1878. In Great Britain the production had not become four times as great as it was nine years ago, the total output in 1870 having been 215,000 tons, and in 1878 807,000 tons. Of Bessemer steel rails the increase in the United States had been from 34,000 tons in 1870 to 600,000 in 1878: while in Great Britain the output had risen only from 300,000 tons in 1873 to 630,000 tons in 1878. In steel made by the Siemens-Martin process the rate of advance in America had been from 3,500 tons in 1873 to 38,000 tons in last year; in Great Britain the advance had been only from 77,000 to 174,000 tons.

NOTICES.

NATIONAL WATER SUPPLY, SEWAGE AND HEALTH.

The report of the Conference held in May last is now ready, and can be obtained at the Society's House, price 1s. 6d. paper, 2s. boards with cloth back.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

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FRIDAY, SEPTEMBER 5, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

PROTECTION OF SHIPS FROM LOSS BY FIRE AND FROM LOSS BY SINKING.

Committee.—Thomas Brassey, M.P., B. Francis Cobb, Lord Alfred Churchill (Chairman of the Council), Rear-Admiral Nolloth, Captain Price, R.N., M.P., Admiral A. P. Ryder (Chairman of the Committee), Captain Henry Toynbee, F.R.G.S., F.R.A.S.

The Fothergill Gold Medal is offered for the best means of attaining the two above-mentioned combined objects. A Silver Medal will be given for the best means of protecting ships from fire. A Silver Medal will be given for the best means of protecting ships from sinking. The receiver of the first Silver Medal may receive also the second, if the means proposed be deemed the best for each of the two objects considered apart from the other, although not deemed the best means of attaining the two objects combined—to which alone will the Gold Medal be awarded. The following are the conditions of this offer:—

Protection of Ships from Sinking, after Collision, after Touching the Ground, &c.—Silver Medal.—The Society of Arts offer their Silver Medal for the best means of preventing a ship from sinking, after collision, after touching the ground, or from any other cause; or for delaying sinking as long as possible by—

I.—Structural arrangements.

II.—Appliances, non-structural.

1. Preference will be given to structural arrangements which occupy the least amount of valuable space, and interfere least with the stowage of important articles.

2. Preference will be given to appliances which are least unsightly, the most ready to hand, and require least "fitting" for immediate use.

3. Preference will be given to structural arrangements least obstructive to free ventilation.

4. Preference will be given to structural arrangements least expensive, as to first cost and repair.

5. Preference will be given to appliances which are least expensive, which occupy least space, which are least liable to injury, and which are most trustworthy.

Competitors are at liberty to draw a distinction between structural arrangements and appliances most suitable to men-of-war, to passenger ships, to ordinary merchant ships; also between the different circumstances attending accidents by day and accidents by night.

Protection of Ships from Fire.—Silver Medal.—The Society of Arts offer their Silver Medal for the best means of preventing or extinguishing fire on board ships by—

I. Structural arrangements for preventing fire.

II. Structural arrangements for aiding in the extinction of fire.

III. Appliances for extinquishing fire.

1. Preference will be given to structural arrangements which occupy least amount of valuable space, and interfere least with the stowage of important articles.

2. Preference will be given to appliances which are least unsightly, the most ready to hand, and require least "fitting" for immediate use.

3. Preference will be given to structural arrangements least obstructive to free ventilation.

4. Preference will be given to structural arrangements least expensive, as to first cost and annual repair.

5. Preference will be given to appliances which are least expensive, which occupy least space, which are least liable to injury, and which are most trustworthy.

Competitors are at liberty to draw a distinction between structural arrangements and appliances most suitable to men-of-war, to passenger ships, to ordinary merchant ships; also between the different circumstances attending a sudden alarm of fire by day, and sudden alarm by night.

Models or drawings of structural arrangements and of appliances must be sent in not later than the 1st of January, 1880, addressed to the Secretary, Society of Arts, John-street, Adelphi, London, W.C., and must in every case be accompanied by a short description.

The Council is at liberty to withhold the Medals if, in the opinion of the Committee, nothing is submitted worthy of the award.

(By order,)

H. Trueman Wood, *Secretary.*

August, 1879.

HEALTH AND SEWAGE OF TOWNS.

THE THAMES AND ITS TRIBUTARIES.

By C. N. Cresswell, Inner Temple.

At the commencement of the present century, the Thames was a pure and wholesome river. Now, throughout a great part of its course, it is the common sewer of Middlesex and Surrey. The Thames has many tributaries; either natural streams, as the Mole, the Crane, and the Brent, converted into open sewers by a process of gradual contamination, or artificial feeders directly conveying the sewage of populous towns into the river bed. This is the practical outcome of sanitary efforts in the Thames Valley during the past 30 years, the history of which period is a tale of doing and undoing, of official meddling and local muddling; of misdirected zeal on the one hand, inert bewilderment on the other. Heretofore the public health had been no concern of Government, but the ravages of cholera in 1847, and the abnormal increase of disease in the centres of population, arrested the attention of the Legislature. In 1848, the era of tentative legislation began, and the Act was passed "for improving the sanitary condition of towns." The metropolis and its suburbs were excluded from this Act, for divers occult reasons not altogether intelligible to ordinary minds. The alleged ground was, that the sanitary condition of the metropolis had, for a period as far back as the reign of Henry VIII., been regulated by Commissioners of Sewers, the powers and jurisdiction of which were extended and consolidated by another Act in the same year.

In 1850, by Order in Council in pursuance of this Act, Richmond was included within the jurisdiction of the Metropolitan Commissioners, and a local inquiry was held by Mr. Donaldson, for the purpose of investigating the best means of improving its sanitary condition. He advised and designed a plan for carrying the sewage to the old Deer-park, belonging to the Crown. The Crown objected, and the Commissioners thereupon resolved to take the whole sewage direct into the Thames. The inhabitants, alarmed by the prospect of river pollution, protested against the profanation, but they protested in vain; the fiat had gone forth, and the sewage soon flowed by two outfalls into the river, one above, and the other below the old bridge.

A system of sewers was constructed at a cost of more than £20,000, and the Commissioners of the period approved the work, persuaded that they had taken an exemplary step in a right direction. There were stringent provisions in the Act of 1848, for perfecting the drainage of towns; cesspools and middens alike disappeared; water-closets became the order of the day, and an augmented volume of intercepted sulliage went on its silent way into the bosom of Father Thames. Nobody seemed to anticipate pollution in that day; "organisms and fungoid growths" were in the womb of the future, dimly descried, perchance, by croakers and crotchet-mongers, but as yet unrealised in the world's philosophy. The town of Richmond having been thus well provided, the good example was not lost upon the neighbouring towns and villages. Twickenham, Isleworth, Kew, and Brentford followed suit with commendable alacrity, and the gas works of the last-mentioned town gratuitously diversified the general current of contamination.

Other towns upon the Thames, outside the jurisdiction of the Commissioners, obeyed the common impulse; until, in 1855, flounders, gudgeon, and other delicate fish refused to face the opposing filth, and the occupation of many a fisherman in the middle reaches was gone. At the same time, the state of the river at low tide forbade the recreation of either bathing or boating to the inhabitants below the village of Twickenham.

In 1861, a Royal Commission reported that the pollution of the rivers of the country had "become a national evil," and, in 1866, Parliament, alarmed by the consequences of its own handiwork, passed the "Thames Navigation Acts," for the purpose of restraining the flow of crude sewage and other refuse into the Thames, or any watercourse within three miles of its channel.

The effect of this change of front upon the local authorities, who were not left long in doubt as to the object of the Acts or the intentions of the Conservators, was general consternation. There were memorials to the Secretary of State, and Committees of the House of Lords, as to the exceptional situation of these riverside towns, where the value of land was high, and the adjacent Crown properties shut them in on either side. Nevertheless, notices were served by the Conservancy as soon as their Act was passed, and the sewage, which the Commissioners of 1850 had carried into the river, could be permitted to pollute it no longer.

The notice of 1867 produced some interesting correspondence, nothing more! It was renewed in 1869, when Richmond had recourse to Parliament. A reprieve of two more years was given, and the authorities again proposed to dispose of the sewage by means of irrigation on land near Maldon. This failed. Thereupon, precipitation was suggested, upon a site in the old Deer-park. The Crown authorities again objected, more peremptorily than before. Then ensued a series of Local Government inquiries, culminating, at length, in a Provisional Order in the year 1872, which was afterwards abandoned as an impracticable abortion. There were a further attempt at irrigation near Hanworth, and, finally, both Kingston and Richmond were advised to adopt precipitation on Ham fields. But all in vain! Mr. Rawlinson decided against Kingston, although the spot selected was within the parish, while Mr. Hawkesley's recommendation of the same site for Richmond provoked a still greater storm of opposition from the local proprietors, on the ground that it was without the district of that sanitary authority.

Driven to bay, Richmond appealed to the Board of Trade, and the award of Capt. Douglas Galton secured for it a further reprieve of two years. The Conservators, during this interval, directed their attention to the neighbouring towns, and local inquiries, held in quick succession, kept the Thames Valley in a condition of sanitary fermentation.

Two years previously—viz., in 1872—there had been held at Kingston a kind of Sewage Parliament, at which Sir Joseph Bazalgette had expounded his plans for purifying the river, from Windsor to the metropolis, by pumping the sewage backwards to land at Woodham-heath, near Chob-

ham. This congress of representatives, without either legal status or power of cohesion, had no result, and the project of Sir Joseph Bazalgette was never fairly discussed. Another less ambitious attempt at combination failed, when Kingston broke away from the projected union, and proposed a scheme of chemical precipitation on the banks of the Thames, near the Borough Gasworks, and opposite to Hampton-wick. The inhabitants of that suburban retreat rose at once, marshalled by the Chairman of the Local Board, and defeated the proposed plan of sewage disposal, on the ground that one already existing nuisance (of a gasworks) could not justify the gratuitous imposition of another.

Hampton-wick itself had not escaped the omnivorous attention of the Conservators, who had, in the interval, served notices also upon Heston and Isleworth, Twickenham, Kew, Brentford, and other riverside offenders. Meanwhile, the Public Health Act of 1875 was passed, amid feelings of general dismay and helplessness, and Surbiton came to the front forthwith, with a plan of uniting the adjoining districts in one combination, under the provisions of that Act. Sir Joseph Bazalgette had projected another scheme for carrying the sewage of the proposed district downwards into the River Thames at Sea-Reach, in combination with the West Kent drainage system, which had just received the sanction of Parliament.

This is known as the "heroic scheme," and after long consideration, and more than one local inquiry, was rejected by Col. Ponsonby Cox, R.E., as a conception which, although practicable from an engineer's point of view, was beyond the needs and limited resources of the Thames Valley district.

To his famous report of January 11th, 1866, he appended certain suggestions as to the best "practical mode of dealing with the sewage" of places situate below Teddington-lock, viz., by "precipitation processes efficiently worked;" and the official promulgation, in the March following, of these opportune suggestions, excited a new sensation, together with a sense of real relief, among the bewildered local authorities.

In October, of the same year, a conference of delegates from each local authority was held, under the presidency of Col. Cox, R.E., himself, at Westminster, to consider tho question of united action, within the provisions of the Act. However, Twickenham and Brentford held proudly aloof from this conference, and it was left for another local inquiry at Kingston, in February, 1877, to determine the limits of the proposed combination. In that year, all the districts named in the application of Hampton-wick, were combined by provisional order, save Heston, Isleworth, and Brentford, and a few other places, which were reserved for after consideration. Twickenham, in spite of vehement opposition, had been scheduled in the proposed combination, but the inhabitants carried their case into the Committee of Parliament; and, after a hard fought contest, made good their contentions, and were finally excluded,

At the end of 1876, Heston and Isleworth, and Brentford, resolved to give effect to the suggestions contained in Colonel Cox's report of that year, and to provide for themselves a system of sewage disposal "by means of precipitation processes efficiently worked," within their own borders.

The projects of both districts were summarily rejected; and the respective local authorities discovered to their cost that the favourable opinion of one Government officer will not secure the assent of another, and that the department in Whitehall does not hold itself bound to the approval of a scheme which has been designed in direct pursuance of the recommendation of its own inspector!

After this disclosure, it is difficult to estimate the exact value or purpose of local inquiries, or even of official inspectors, unless the reports be read in a sense exactly opposite to that which the authors intended.

Discomfited and disheartened, Heston and Isleworth sought refuge in the united fold. Brentford, like the Peri, still sits expectant at the gate of Paradise.

All eyes were now turned to the "United Drainage Board" for the solution of the vexed question, by means of a mature and well-digested scheme of sewage disposal for the whole district.

It came at last, after much pain and long gestation, under the auspices of Col. Haywood and Mr. Peregrine Birch, in the guise of a colossal project for pumping the sewage over 800 acres of land near Moulsey; whether by crude irrigation merely, whether by irrigation and precipitation, or downward intermittent filtration combined, the outside world has never heard.

We assume, of course, that the engineers had considered the exact method of disposal; but these details were never discussed publicly by the Board, and the most eager inquirer failed to extract any definite information as to details, or estimated cost, of the system to be ultimately adopted. Great names were freely used as sponsors for the superior excellence of the selected plan. Nevertheless, the minds of the ratepayers were disquieted within them, although such men as Dr. Frankland, Col. Jones, V.C., Mr. Chalmers Morton, Dr. Tidy, Mr. Hawkesley, "*cum multis aliis*," had been vouched as to the fitness of the site for irrigation, and the Parliamentary Committee certainly revealed no abatement of confidence. One thing was certain—there would be no local inquiry, as prescribed by the Act which created the Board! To Parliament itself, at one bound, they had resolved to go for a special and enabling Act.

It was, at the same time, announced that the process eventually to be adopted was a mere matter of detail to be considered thereafter. This resolve provoked an outburst of widespread alarm and agitation. Every interest, far or near, local or metropolitan, public or private, personal or official, real or sentimental, combined to resist the threatened intrusion; while certain gratuitous clauses in the Bill for closing their intakes at Thames Ditton, brought all the water companies into the field—a solid phalanx armed to the teeth to do battle for their special rights and privileges.

The contest had waxed furious, when a circular from the United Board was issued to the several constituent authorities, calling their attention to the transparent necessity of separating rainfall from sewage throughout the district to be bene-

fited by the project. We doubt not that the engineers had well considered this indispensable condition of sewage disposal. It is clear that the Board, in its deliberative capacity, had never discussed it. Certainly the constituent authorities had not; and when Richmond and Kingston received the circular for consideration, they flatly refused to give any opinion, or bind themselves beforehand at that stage of the question.

The prospect of having to construct yet another system of sewerage in their much belaboured streets and byeways alarmed the ratepayers of these two towns, and their zeal for the new project visibly abated.

The less populous districts, yet unsewered, easily assented to the proposal; but there were heart-burnings abroad, and smothered defection within, and whilst the agitation was at red heat, the House of Commons extinguished the conflict and strangled the Bill upon its second reading. The result has been received with unruffled equanimity by the ratepayers, who await with patience the next scene in a strange eventful history.

You will find its parellel in almost every watershed of the Kingdom. Everybody indeed everywhere is bent upon ridding himself of sewage, and removing the nuisance from his own doors; but nobody thinks, or cares to think, what becomes of the volume of sewage, providing that it be removed beyond his borders.

The dwellers on the banks of the Thames know full well what has become of it. Borne on the tide in uniform oscillations, the filth flows on for ever, even into metropolitan water below Battersea, under the very noses of those who fondly thought to have rid themselves once for all of the nuisance by the main drainage system of the metropolis.

This colossal work, with its pumps and culverts, and all the massive grandeur of the Thames Embankments on either shore, is an achievement worthy of its author. Nevertheless, when regarded from that point of view which will find most favour in this Conference, the whole scheme of interception has stopped short of its just fulfilment, and in regard of wasted wealth, and neglected opportunity, has become a national humiliation.

It is cheaper to waste than to utilise it, argue the professors in paradoxical fashion. It is an unworthy excuse; and only another mode of saying "We have not yet found the right method, and there is not sufficient public spirit to take the trouble of searching for it."

Twenty years ago, Cubitt, twice Lord Mayor, declared that the system of sewage interception, combined with the pumps of the water companies, would effect a diversion of the River Thames to the extent of one-fourth of its average volume above Teddington-lock. It is, indeed, far more. That volume, supplemented by the rainfall of the metropolitan area, and polluted by the excreta and ablution of millions of men and animals, is poured daily into the river! 120,000,000 gallons of diluted filth in the immediate vicinity of the populous suburb at Woolwich!

The condition of the river below Barking-creek in the heat of a summer's morning, at mid ebb, beggars all description. The mariner, fog-bound and becalmed, as each turn of the screw stirs up the film and slime floating on the surface, can appreciate at his leisure the well-remembered words of the late Mr. Newton, chairman of committee of the Metropolitan Board of Works. "We have got rid of our sewage" (he is reported to have said in Jan. 1873) "and with the sanitary aspect we have nothing to do."

Nobody, in truth, appears to have anything to do with the sanitary aspect of metropolitan drainage. It is true there is the Rivers Pollution Prevention Act of 1876, but as in 1848, so now in 1876, the metropolis is above the law of the land.

There are Conservators of the River also, and their engineers and Captain Calver, report ever and anon; yet the Conservators do absolutely nothing, paralysed, it may be, by the enormity of the transgression, or aghast at "that matchless intrepidity of face" with which the authorities in Spring-gardens avow the deed, and openly seek to justify it. In justice to the Conservators, I may remark that by their Act of 1867, the duty of preserving the purity of the water of the Thames extends downwards to the western boundary of the metropolis, and not farther, in respect of pollution arising from sewage outfalls. Within their own limits, the Metropolitan Board have violated both the letter and spirit of their Acts, the avowed object of which was "the purification of the Thames." Certain is it that, whatever the technical construction of the statutes, the Legislature at that time contemplated, and the public expected, the utilisation, not the total waste, of the sewage of the metropolis.

Meanwhile, the mischief accumulates, and although the Corporation of London has made some sign, and the Secretary of State is invested with power under the Act, upon complaint made, to direct an inquiry, and take proceedings thereon, nothing has been heard of any application by the Conservancy for the intervention of Government.

Shall it be left to the Council of this Society to beard the authors of a sanitary iniquity? They have done much already to win the gratitude of their country, but action in a matter of this magnitude is surely the work of Government rather than of a scientific association. It is our task to investigate facts, and state conclusions for the guidance of others upon whom lies the responsibility of action.

The conclusions already published by the Council, after our first Conference, have been amply confirmed and established by the experience of the past three years.

Sewage irrigation, chemical precipitation, and downward intermittent filtration, each has had its champions and its battlefields, but the truth lies after all in the *juste milieu*, in the adaptation of different methods to different localities, and oftentimes in a happy combination of them all. Within these broad lines lies all "the law and the prophets" of sanitary science as applied to sewage disposal.

Since the date of the Society's report in June, 1876, the fallacies of some, and the panaceas of others, have been alike refuted, and it is only by working on the lines and in the spirit of that report that we can hope to thread our way through a labyrinth of crotchets and misconceptions.

Unsuccessful promoters and local politicians are apt to rail at popular ignorance or apathy, but the fault lies with the leaders of the people; and those who cavil at the decision of Parliament on

the Thames Valley Drainage Bill, should take heart of grace, and all strive alike, whether Liberals or Conservatives, to educate their party, if they ever hope to grapple effectually with the sewage monster.

At this juncture, neither Parliament nor the public are in earnest, whilst the Circumlocution-office in Whitehall stands with folded arms, waiting, peradventure, for a more convenient season than the eve of a general election, or for a new revelation in the guise of another national pestilence.

SOME EXPERIENCES OF SEWAGE EFFLUENTS, AND BURNING SLUDGE INTO CEMENT.

By Granville Cole, Ph.D.,

Late Student under Drs. Frankland, Hofmann, and A. Claus, Member of the Berlin Chemical Society, &c.

During the past year, it has been my duty to watch the process for purifying the sewage now being carried out at Burnley, in Lancashire.

1. In a paper, which was read by Mr. Richards last year at this Conference, the method of dealing with water-carried sewage by General Scott's system of precipitation by lime, and utilisation of the sludge for cement, was described. Examples of this process with the cement are exhibited in the Society's room below.

2. This process has now been carried on for nearly eighteen months. The sewage is purified, and the effluent—samples of which have been submitted for analysis to two of the highest chemical authorities—is certified by one to be fit to be poured into a stream of ten times its volume, by the other to be fit to be poured into a stream, having a velocity of at least three miles an hour, of fifty times its volume. Both these conditions are fulfilled at Burnley.

3. This effluent could be further purified at a comparatively trifling cost to towns by intermittent downward filtration, requiring only one-sixth of the land, which, according to the Rivers Pollution Commissioners' 4th Report, unprecipitated sewage requires.

4. The Corporation of Burnley have not required that this should be done, but the injunctions against the town have been suspended. In the case of Burnley, the stream into which the effluent is poured varies very much, according to the weather. In wet weather I have seen the Pendle water, as the stream is called, rise several feet in as many hours. I abstain from giving the many analyses I have made of the effluent water, and comparing it with the averages given by the Rivers Pollution Commissioners. A fair average could only be obtained, in my opinion, after daily observations, extending over a year.

5. The rainfall at Burnley is exceptionally high, and the neighbouring hill, the Pendle, collects and pours the rain into the Pendle water. The Pendle water itself rises not far from the small old town of Colne, and receives the raw sewage as it flows by. It then flows past the township of Nelson and the village of Barrowford, on the west of the village of Brierfield, from all of which places it receives more raw sewage before it reaches Burnley. A scheme is now under consideration for the federation of these places, in order to bring their sewage to the Burnley sewage works for purification. Should this scheme be successfully carried out, the Pendle water will certainly be one of the cleanest streams in Lancashire. I have several times noticed that the stream is very much dirtier than the effluent poured into it from the Burnley sewage works.

6. Portland cement is manufactured from chalk or limestone and clay. The component parts of these materials vary very slightly and, therefore, the manufacture is nearly constant. The average analysis of five large manufactories gives the following results, viz:—Lime, 56·21 per cent.; silica, 24·44 per cent.; iron, alumina, 12·1 per cent.

7. The manufacture of Portland cement from sewage is much more precarious. Sewage, according to my experience, varies in every place, and during every hour, and, consequently, has to be carefully watched in order that the requisite quantity of milk of lime may be added. At Burnley, on certain days, large quantities of dye water come down, on other days butchers' refuse, and once or twice we have observed the sewers full of coal-tar and oily refuse; all these facts have to be carefully observed, and only after careful experiments can the quantity of lime necessary to precipitate the sewage be determined. The resultant sludge at Burnley on an average only contains 46 to 50 per cent. of lime and, therefore, before it is fit to be burnt into Portland cement clinker, more lime has to be added. This is done after the supernatent water has been run off the sludge deposited in the tanks. The sludge has afterwards to be passed through a pug-mill in order that a uniform compound may be obtained.

8. At Birmingham, where Portland cement was also made, the sewage is so capricious that a uniform manufacture could not be guaranteed. This is accounted for, by the fact that at certain times very large quantities of acid from the hardware manufactories of the town are poured into the sewers.

9. At Portsmouth, where I have studied the sewage, which has wholly water-closet and house drainage, there is little or nothing to interfere with the manufacture of a high class Portland cement: I believe the same remark would apply to the lower Thames valley sewage. The sewage requires only a small quantity of lime to defecate it; 16 grains of quick lime per gallon is ample. The sludge I have found generally contains from 58 to 60 per cent. of lime, and, therefore, no fresh lime would have to be added. The fact that at Portsmouth the storm water is partially kept out of the sewers is also greatly in favour of the manufacture of good cement. And in places where the separate system is in force, and where the proportion of water-closets is large, it would be, perhaps, worth while to allow the finely suspended organic matter to subside before liming, and to treat the organic matter described in General Scott's patent.

10. The sludge resulting from limed sewage may also be burnt at a lower temperature than that necessary to produce Portland clinker, and be re-used to precipitate the sewage. After this has been done several times, the lime becomes rich in phosphates, and may be profitably sold as a first-class agricultural lime.

11. As a result of my experience, I have arrived at the following conclusions :—

a. The sewage of every town should be carefully watched and experimented on, before any plans or estimates are made.

b. The storm water should, if possible, be kept out of the sewers.

c. A paved town is more favourable to cement manufacture than an unpaved one.

d. That manufacturing refuse, except acids, does not materially interfere with cement manufacture.

12. In conclusion, I may state that the cement now being made at Burnley is much improved in quality since the manufacture began, and much has been sold. The latest tests give excellent results. Mr. Deacon, borough engineer of Liverpool, reports the tensile strain of 695 lbs. on the $1\frac{1}{2}$ inch square, and that the cement passed through a sieve of 50 meshes to the inch, leaving only 7 per cent. of residue. The latest test at Burnley gives 698 lbs.

13. A portion of a sea-wall at Portmouth has been built with it, and it has stood this test remarkably well.

14. Much has been learnt since the process was first started at Burnley, and it may be fairly expected that towns will obtain purification, and at the same time will recover the greater part of the cost of so doing, by adopting this process.

TEN YEARS' PRACTICAL EXPERIENCE IN SEWAGE TREATMENT.

By Fritz Hille, C.E.

The sewage question stands now as it stood twelve months ago, when the Conference of the Society of Arts was held in May, 1878; no progress, no further discovery has since been made in the treatment, utilisation, and in the disposal of town sewage, and, having no further remarks to add to those contained in the pamphlets written by me on this subject, I now submit, as a possible matter of interest to those concerned in or connected with the sewage question, the results obtained during the last ten years from practical every-day use of the method of sewage disposal advocated by me. I shall refer to towns where my system of sewage treatment has undergone the test of time; giving correct statements of cost for labour and chemicals, and other figures and testimonials which show and prove unquestionable success.

Wimbledon.

The Wimbledon Local Board, from 1870 to 1876, were entirely free from litigation in respect of the disposal of their sewage, there were no complaints, and my method of treating the sewage gave satisfaction to the authorities.

Edmonton.

The Edmonton works serve as a model for places similarly situated. The effluent water gives satisfaction to the local and the river authorities, and the sludge has proved no difficulty; the stuff is inoffensive, and as a good manure finds ready customers. The osier beds answer very well.

The system has stood the test of time and of practical every day use very well indeed.

The cost at Edmonton, for a population of 16,000, for chemicals is £4 8s. 10d. per week; or—including wages, pumping, and materials—per annum about £750; royalty, £100; total, £850; or, cost for chemicals and royalty, about £350—equal to $5\frac{1}{4}$d. per head of the population; or, total cost of works about £850—equal to 1s. 1d. per head of the population.

In the beginning of 1878 some eight acres of land were laid out and prepared for watercress beds, to be supplied with the purified effluent from the deposit tanks, and the operation of growing watercress with such water has proved quite a success, so much, that double the quantity of land will be used this year for the same purpose. This land lets at £10 per acre.

A description of the Edmonton Sewage Works is given in my "Remarks on the Sewage Question," of 1877.

I append testimonials from the clerk to the Local Board of Health:—

Edmonton,
December 6th, 1876.

Dear Sir,—I am directed by the Edmonton Local Board to reply to your favour of the 30th ultimo, that they have pleasure in informing you that they acknowledge the satisfactory results of your process now in use at the Edmonton Sewage Farm.

Your process has satisfied the requirements of the River Lee Conservancy Board, and it appears to the Edmonton Board to be at present the best known process.—Faithfully yours,

(Signed) Chas. S. Houlder, Clerk.

F. Hillé, Esq., Chiswick, W.

Tottenham.

I have treated the sewage of this town for more than three years, and the following letters refer to the result, *i.e.*—

Asplins, Tottenham, November 6th, 1377.

Dear Sir,—Having used on my farm a considerable quantity of manure obtained from the works of the Tottenham Local Board, I can now give the results. I find it exceedingly beneficial in the production of cabbages, imparting that good colour almost unobtainable from other manures. Tares and rye thrive remarkably well, as also do white turnips. My experience with meadow land last season was of a limited character, but I was so far satisfied that I have lately well manured upwards of 30 acres of grass land, which will enable me, later on, to speak from facts.

As a general rule, I do not take any notice of written testimonials, knowing them to be mere advertisements; however, in this case most of the crops are to be seen, and they will speak for themselves.—Yours truly,

(Signed) Wm. B. Delano.

W. A. H. De Pape, Esq.

Tottenham, 3rd June, 1878.

Dear Sir,—I have much pleasure in bearing my testimony to the success which has attended your treatment of the sewage of this district ever since its commencement in the month of February, 1876.

We have since that time had no complaint from the River Lea Conservancy as to the quality of the effluent water we discharge into their river.

We have for some time past had no difficulty in getting rid of the sewage deposit (sludge) which is being used as a manure; and the sewage works have entirely ceased to be complained of as a nuisance by those inhabiting the neighbourhood in which they are placed.

Wishing you the same success in other districts where your system may be applied,—I have the honour to remain your obedient servant,

(Signed) Arthur R. Abbott,
Chairman to the Tottenham Local Board of Health.

F. Hillé, Esq.

The cost of chemicals used from the 17th of February, 1876, to the 17th of February, 1877, for treating daily from one million and a half to two million gallons of notoriously bad sewage, amounted to—

	£	s.	d.
For 353 cubic yards of Lime at 13s. 6d. per cubic yard	£238	5	6
For about 1,000 gallons of tar	25	0	0
For chemical salts	208	0	0
	£471	5	6

Southborough.

The letter underneath speaks for the results.

Southborough Local Board,
8th August, 1878.

Dear Sir,—In reply to your letter of the 7th ult., I am instructed to inform you that for some years past the Southborough Local Board have experienced great difficulty in the treatment of the sewage of their district, so as to prevent any nuisance to the stream into which the effluent water runs, and have tried numerous systems of purification, all of which turned out more or less failures.

It was not (as you are aware) until after the Board had decided upon purchasing land for a sewage farm that your process was adopted at Southborough, and the Board consider that, although the existing tanks are very inefficient for the proper carrying out of your system, such process is decidedly the best of those the Board have tried, particularly as regards the quality of the effluent. The Board are also of opinion that the cost of the process is reasonably cheap, and believe that in many instances (particularly where suitable land cannot be obtained) Sanitary Authorities would do well in adopting your patent system for purification of sewage. I am, dear Sir,

Yours truly,
(Signed) George Delves.
Clerk to the Southborough Local Board.

F. Hillé, Esq., Engineer, Chiswick, W.

Taunton.

After the Taunton Sewage Works had been three months in operation, on the 28th of December, 1877, at a special meeting of the town council to consider, and after careful inspection and thorough investigation, to report upon the efficiency of the works, and upon the results obtained from the use of my process for the treatment of the sewage, the following resolution moved by the mayor was passed:—

"That the Taunton Sewage Outfall Works have fulfilled the expectations of their promoters and the requirements of the town."

[Since this paper was read, the Borough Surveyor of Taunton has written to the Secretary, stating that Mr. Hillé's system "has been discontinued for the last fifteen months."—Ed. *Soc. of Arts Journal.*]

Leicester.

The following letters refer to the results obtained at the Leicester Sewage Works:—

Leicester, October 16th, 1877.

We have applied Mr. F. Hillé's patent process for the purification of the effluent water from our sewage works for the months of May to September, both included. Considering the filthy condition of the banks and bed of the river, the fouling of years past, the very limited area of settling tanks, and the small lengths of weirs in proportions to the large volume of sewage passing the works, viz., 6,000,000 gallons per diem, the water in the river was greatly improved by the application of the process, The occupiers of lands immediately adjacent to the works, and the occupiers of the Belgrave Lock House, which is surrounded by the effluent water, declare the beneficial effects on the atmosphere, which they all state has not been so free from pollution for 20 years.

The action of the salts is so effective in cleansing the covered tanks, that the labourers employed in emptying them give the process the highest praise as enabling them to do their work without nuisance. I have no hesitation in saying that I believe under more favourable circumstances the effect would be perfect.

(Signed) E. L. Stephens,
Borough Surveyor.

Fritz Hillé, Esq., Chiswick.

The Nurseries, Leicester Abbey,
22nd June, 1877.

My Dear Sir,—I have been much struck with the beneficial effects of Mr. Hillé's process on the river water adjoining my meadow. I have watched the river daily, and have no hesitation in saying that I have never seen the water during the last 20 years so free from all smell and offence.

I am, dear Sir,
Yours truly,
(Signed) Thomas Warner.

E. L. Stephens, Esq.,
Borough Surveyor, Leicester.

As to cost, the figures underneath speak for themselves:—

Cost of Chemicals, Fees, and Travelling Expenses.

1876.	Hillé's Process.	£	s.	d.
May.	Total cost for Lime, Tar, Salts, Fees, and Expenses	187	9	2
June.	Do. do. do.	164	18	5
July.	Do. do. do.	158	18	3
August.	Do. do. do.	130	0	11
September.	Do. do. do.	135	13	2
	Total	£776	19	11

The figures given above show that the total expenditure for chemicals during the five summer months amounted to £776 19s. 11d., or, on the average, £156 per month, including travelling expenses; according to this, the annual expenditure would be about £1,872; but a considerable part of that amount could be saved by a judicious arrangement of summer and winter treatment. The yearly outlay of £1,872 for 120,000 inhabitants represents not quite 4d. per head of the population.

It will be seen, when comparing the cost at Leicester with other towns, that the expense for the chemical treatment of large volumes of sewage according to my plan, is not greater, but rather smaller, in proportion to moderate quantities, for instance—

	Inhabitants.		Per ann.		
Leicester, with	120,000	at the cost	£1,872	equals 4d.	per head of population.
Tottenham ,,	34,000	,, ,,	575	,, 4d.	
Edmonton ,,	16,000	,, ,,	350	,, 5¼d.	
Taunton ,,	16,000	,, ,,	300	,, 4½d.	
Southboro' ,,	4,000	,, ,,	100	,, 6d.	

Aldershot.

Reference has been made in my pamphlets to the Aldershot (Town) Sewage Works, which were completed in December, 1877. Since then I have treated the Aldershot sewage, and I am able to state that the sewage works and the plan carried out give satisfaction to the authorities. The total cost of these works, which are large enough to deal with the sewage of 15,000 people, is under £3,000, inclusive of about three acres of land, and comprising, inlet chamber with gratings and screens, valves and storm-overflow, pumping well

and reservoir, three deposit tanks provided with syphons and overflow, pumps for lifting sludge and cleaning tanks, sludge beds, two engines with pumps, boilers, and all necessaries for lifting the sewage, and all mixing apparatus, and pump for pure water supply.

The works serve well as model for towns similarly situated, and they practically show how a great deal can be done with the expenditure of comparatively little money.

WINDSOR.

The Windsor Sewage Works were designed by Messrs. Thomas and Charles Hawksley, and have been carried out in substantial and costly style; they well deserve a visit of inspection, as they show, like all Messrs. Hawksley's works, perfection in every detail. The sewage is carried from Windsor by means of an intercepting sewer, 4ft. 6in. in diameter, and about three miles in length, to the pumping well at the outfall works, and this sewer serves for all practical purposes as storm reservoir at the same time. From the pumping well sewage and chemicals mixed together are lifted and delivered into three deposit tanks, and from these the effluent is either discharged through an outfall chamber into the river, or it is turned upon filtering beds and finds its way thus into the Thames.

The effluent at Windsor is of a very fair quality, and there is no difficulty in disposing of the sludge, the whole of which is used on the land as manure. The Windsor sewage has been treated by me since the works were opened in October last, and they answer well the purpose for which they were intended.

The Sewage Works at Birkdale and Somerton will soon be finished, and there are several large towns which have definitely adopted my plans for outfall works, and my method of sewage disposal. Of those places I intend to give an account at some future occasion.

SEWAGE DISPOSAL AT WREXHAM.

By Lieut.-Col. Alfred S. Jones, V.C., Assoc. M. Inst. C.E.

In the course of former Conferences, and elsewhere, the details of my experience in dealing with the town sewage of Wrexham have been given to the public for six years, and it seems possible that the following preliminary remarks may not be out of place, as an introduction to my balance-sheet of the seventh year, ended 2nd Feb., 1879.

First, I feel very thankful that I have been able to carry my experiment so far, without interference from those more serious accidents which are apt to break the course of all human undertakings, and that I have lived with my family of six healthy children within some 250 feet of a sewage carrier, while Mr. Jackson, dairyman, residing in the centre of the farm, has been equally fortunate with another young family, so that our experience supports the conclusion, established in many other places, that the proper utilisation of town sewage need not cause a nuisance injurious to health.

But, in taking up the subject, I considered that its sanitary effects required little further proof, and I directed my attention mainly to the financial problem, regarding which public opinion was just then (1872) beginning to recoil from extravagant views of the profit to be derived from sewage, which had been set forth by various enthusiasts, and was then in danger of rushing to the other extreme, in viewing sewage as a source of inevitable and excessive loss.

If I have contributed in the smallest degree to check this recoil, and, acting like the natural force of gravity, have helped to bring the pendulum to rest in its true vertical position of equilibrium, midway between the extremes, I cannot have laboured in vain. But the knowledge that many engineers and others have been brought to recognise one fundamental error, which has marred the

HAFOD-Y-WERN FARM.—BALANCE-SHEET FOR THE YEAR ENDED 2ND FEBRUARY, 1879.

1878.	£	s.	d.	1879.	£	s.	d.
Feb. 2.—To outstanding debts........	154	19	9½	Feb. 2.—By receipts for the year ended this date	1,074	8	1
,, valuation of live and dead stock	818	4	0	,, sundry debtors	62	15	1½
,, ,, permanent improvements, viz., £807 6s. 4d., less £40 paid per last balance sheet to sinking fund	767	6	4	,, valuation of live and dead stock	949	10	0
1879.				,, ,, permanent improvements	792	6	4
Feb. 2.—To wages for year ended this date	446	11	6½				
,, rent, rates, taxes, &c., do.	473	1	0				
,, other payments, do.	98	18	0				
Interest on capital, viz., 5 per on £1,800................	90	0	0				
Balance profit on year's farming*, by Lieut.-Col. Jones.	29	18	10½				
	£2,878	19	6½		£2,878	19	6½

* It should be noted that this is over and above any profit realised by Mr. Jackson, the dairyman, keeping his own cows and living upon this farm, paying for the keep of his cows, &c., such payments being accounted for in the gross receipts, &c., on the other side of the above account.

sewerage of nearly all our towns, forms my chief cause of satisfaction. That rough and ready plan of mixing up sewage with surface and subsoil water has indeed been fatal to the effective use of sewage, and this evil, intensified during several wet seasons, has had its influence upon my balance-sheet in a very unpleasant manner.

It will be seen, from the above account, that I am compelled to postpone, to a more favourable season, the payment to sinking fund which has appeared in previous balance-sheets, because, after deducting 5 per cent. interest on capital, there remains but a very small margin of profit on the seventh year's farming.

Indeed, looking at this balance-sheet by itself, one might well feel discouraged. But I have long been convinced that no fair judgment as to the results of farming can ever be arrived at from any single year's accounts, where so much depends upon the season, and the nature of the stock on hand at the beginning and end of the period, together with their market prices.

But, at page 46 of the second edition of my pamphlet, I have indicated a safe and simple mode of lumping the accounts of several years, whereby, when every receipt and payment has been extracted from the cash-book, it is only necessary to add outstanding debts and valuations of the stock, &c , at the end of the period, to the total receipts, and to subtract from that sum the total payments; thus—

	£	s.	d.
Cash receipts of first five years, *vide* page 46 as above	7,245	2	10½
Cash receipts, 1877-8	1,188	4	8
Do. 1878-9	1,074	8	1
Outstanding debts, 2nd February, 1879	55	5	1½
Valuations—Stock ,, ,,	949	10	0
Do. Permanent improvements ,,	792	6	4
	£11,304	17	1
Total produce in seven years, resulting from total payments as per other side	9,527	1	6½
Excess of results, over total payments producing those results, being gross profit of the seven years' business ..	£1,777	15	6½

	£	s.	d.
Deducting 10 per cent. for seven years, for interest and repayment of capital, this gross profit of	1,777	15	6½
Less 10 per cent. on £1,600 = 160 × seven years =	1,120	0	0
Leaving	£657	15	6½

As the net profit over 84 acres for three years, and 104 acres for four years (say an average of 95 acres for seven years), and £657 15s. 6½d. divided by 95 × 7 = 665, gives 19s. 9d. as the net average annual profit per acre.

	£	s.	d.
Cash payments, first five years	7,428	8	3½
Do. 1877-8	1,080	2	8½
Do. 1878-9	1,018	10	6½
	£9,527	1	6½

Having never been absent more than a week at a time during the last seven years, I am personally responsible for the record of the Hafod-y-Wern farm accounts, and when due allowance is made for my own deficiencies, and want of early agricultural training, as well as for the very high rent of the land, and excess of water mixed with the sewage, it will, probably, be concluded that the question, "Will a sewage farm pay?" may be answered in the affirmative; at any rate, it is my firm conviction that, given the right sort of land and undiluted sewage, a farmer may certainly pay a rent of £4 to £5 per imperial acre, and make a fair profit for his time and capital.

In my remarks at page 75 of the proceedings at the Conference of 1878, I described the commencement of experiments upon the drying of sewage sludge, and preparation of a useful general purpose artificial manure, by the subsequent mixing of a due proportion of bone meal and sulphate of ammonia with the dry poudrette, and I still hope that this compound will deserve its name of the "Farmer's Friend,"

While recognising the theory that a thorough scientific farmer may do better by analysing his soil, and applying exactly the right proportion of those elements of plant food which, by that means and by previous observations, he may judge to be wanting for the production of the particular crop he desires to grow (for in that way he might reduce the cost of transport and spreading of his manure to a minimum) my knowledge of human, and especially of farmer, nature leads me to believe that it will be long before our crops are generally grown upon exactly that principle, however desirable it may be to keep it fully in view as an object of agricultural education.

I can well remember the lessons I learnt as a boy, from an old landowner and farmer in Leicestershire, whose creed was, that "where there is muck there is money," and who treasured up his farm-yard manure and anything he could make into compost, knowing that it would be equally efficaceous for grass, corn, and turnips. This gentleman and his successors were ready enough to see the value of Peruvian guano as it used to be when first introduced into this country, good for all crops and soils, but he and they have hardly yet been educated to Mr. Lawes' pitch of perfection, which might enable them to apply with safety, and to buy without being cheated, nitrate of soda for one field, and the cheapest combination of phosphoric acid or potash required for another.

Manure makers in every district have recognised this natural demand of the farmer for a compound manure, which he may safely apply directly from the bags in which he receives it, without any of that careful mixture with sifted ashes, soil, salt, &c., which the highly educated farmer knows he must make with his sulphate of ammonia or nitrate of soda, to insure its even distribution, and they have traded on the farmers' ignorance by supplying him with special manures for grass, corn, potatoes, turnips, and mangold, differing little, if at all, except in name and price, but all containing more or less nitrogen and phosphoric acid, and weighted with a commission of 20s. or more per ton, for the benefit of the agents who attend every market, soliciting orders in keen competition with each other.

Having dried my sludge to a poudrette, very much resembling the basis of such compound manures, and worth by analysis about 30s. per ton. I applied to the best authorities to suggest an addition of phosphate of lime and nitrogen, which

mixed with my base, would give a manure likely to take well with the farmer, as efficacious for all crops, and I felt that my neighbours would have confidence in my maintaining exactly the proportions once fixed

The "Farmer's Friend" consists of

1 cwt.	sulphate of ammonia.
7 ,,	fine raw bone meal.
12 ,,	dried sewage sludge.
1 ton.	

and buying my bone meal and sulphate at a distance, I can sell the compound with a fair profit at £6 10s. per ton in bags, or about £2 per ton cheaper than the best of the compound manures in the market. But, with a steady market, ensured for such a manure, it might be made at every town's sewage works as low as £5 per ton, by collecting and grinding the bones, and making sulphate from the liquor of the local gas works, all on the spot where the sludge is dried, and thus saving, not only the carriage, but the manufacturing profit upon each of the ingredients, which, for want of expensive plant, I have to import from a distance, although every town which produces sewage, will yield also bones and ammoniacal liquor for sulphate, if people will take the trouble to collect those raw materials on the spot, and prepare them at the sewage works for admixture with the dried sludge.

Such a saving as some 40 per cent. on his present manure bill, which the difference between £5 and £8 10s. would afford, should be worth striving for, and the example of the Civil Service and Army and Navy Co-operative Stores, in dispensing with the convenience of retail shopkeepers calling for orders, and putting down goods on unlimited credit, may tempt farmers to send to the nearest town works with cash for their manure, instead of yielding, as they have done, too much to the persuasions of touting agents.

Farmers are partial to old friends, however, and not very ready to take up with new ones, so I must be patient, and shall not lay out the additional capital for bone meal machinery and sulphate making, until I see a steady demand for "Farmer's Friend" at the price of £6 10s., or something less, at which it pays me to prepare it with my present appliances; but the experience I have had in selling 172 tons last season, and a corresponding quantity so far during the present one, is sufficiently satisfactory, and the reduction of nearly £2 already offered to the farmer, ought to be a good move in the right direction.

There seems to be a sort of fatality attending those who take up the sewage question superficially, inclining them to exaggerate the value of sewage, and even that of the comparatively worthless sludge which they fancy can be turned into gold at a moment's notice, by the aid of a "Limited Company" with the stock exchange manipulation of its shares, and I regret that Mr. Kidd, the patentee of a drying machine I referred to at the last Conference, became shortly afterwards a victim to this sewage malady, and was soon discontented with the tentative policy which I had established, in my capacity as sole manager of the Wrexham Manure Company from its formation. He has since formed a limited company with which I have no connection, but which I understand is about to imitate, on a far bolder scale, at the neighbouring town of Oswestry, the experiment which I continue to carry on cautiously at Wrexham.

In buying Mr. Kidd out of the Wrexham Manure Company, as I was compelled to do by the access of this fever in June last, I acquired the right to use two of his machines anywhere free of patent rights; but having, while the negotiation was pending, procured a machine of totally different construction, though utilising the same valuable principle of bringing the substance to be dried into direct contact with the smoke and gases of combustion from the heat producing furnace, I have found the new machine quite satisfactory, and sufficient for all my work at present, so that I have not yet made any use of my right to work Mr. Kidd's patent since he ceased to be connected with my Wrexham Manure Company.

The machine I am now using is the invention of Mr. W. A. Gibbs, Gillwell-park, Essex, a gentleman who has devoted himself most patiently, for many years, to experiments in drying hay, corn, and a great variety of other articles.

I adopted Mr. Gibbs' machine with the double object of drying Italian rye-grass for hay, as well as for sludge drying, thus securing work for it throughout the year; and last autumn I made a stack four yards square of hay, put together just as it came out of the drying machine.

The process was as follows:—A load of green grass, preferably fresh from the scythe, but often sodden from lying in the swathe under rain, was drawn alongside of a chaff-cutter mounted on a platform over the feeding end of a long revolving iron cylinder, which constitutes the drying machine. A 2 h.-p. steam-engine turned this cylinder, a fan which drives the fire gases through it, an elevator to carry the dried hay on to the stack, and the chaff-cutter through which the green grass was passed in the first instance, and whence it dropped into the feeding hopper of the revolving drying cylinder.

The chopped hay thus produced contained from 25 to 30 per cent. of moisture, and to all appearance was fit for stacking in the ordinary way, but, from being chopped, the moisture from subsequent sweating had not the same chance of escape as ordinary long hay affords, and, consequently, the stack was spoiled by mould because it remained warm and damp for about two months, instead of going through the more rapid, and sometimes dangerous, heating of an ordinary haystack.

Italian rye-grass grown from sewage is so succulent and heavy a crop, that it requires more care and time to save it than ordinary hay grass; but I have made a stack of it every year with such success, that my own horses and cows live upon it through the winter, as a rule, and in our uncertain climate a drying machine is a great desideratum, for this reason, viz.: that there is no crop which can be produced to greater pecuniary profit on a sewage farm than Italian rye-grass, if even two out of the six annual cuttings can be sold green on the ground; and, therefore, it is an object to have enough land under this crop to supply the local demand for green fodder in a dry season, even at the sacrifice of great waste of grass at times, when this demand is slack, as it will be at all seasons of growth on ordinary pasture in the

neighbourhood, because people will not buy when they have grass on their own fields.

It thus happens that if the expense of cutting and drying can be covered (about 15 shillings per ton of dried hay), any margin between that and the price of the worst hay remains for profit, quite enough to induce great efforts to attain perfection in the drying process, which I have endeavoured to explain.

I shall now pass on, with your permission, to notice experiments relating to town sewage, and the pumping of sewage to land not commanded by gravitation, experiments which are especially interesting to me, from their having arisen out of the acquaintance of the Mayor of Wrexham with my farm, and because the first application of his new pneumatic system is now in course of demonstration upon my land.

At one of the earliest of these Conferences, I threw out the idea that it would be well if engineers, in undertaking works of sewerage, would adopt more definite plans, founded upon such data as are used in laying on water supply to towns.

Excluding rain and subsoil water under the separate system, which has at last fought its way to the front, it is clear that the water supply of a street or a town, is as nearly as may be, the measure of the fouled water or sewage which requires removal from the same locality; and I suggested that engineers, who are careful to proportion the water-pipes and pressure to such quantities, might easily apply the same data to the size and fall of sewers, instead of making the latter three or four times as large as the corresponding water-pipes, and thus ensuring a very slow current and ample gas-holding space in pipes which convey the gas generating liquid, while they provide for the clean water pipes running always full.

In thus advocating the speedy removal of sewage, by pipes kept as nearly full and running as fast as possible, I thought only of applying the natural force of gravity; but Mr. Isaac Shone, an engineer from my own town, seized upon the idea, and extended to its utmost limit the reduction of gas-holding space, by providing for the constant movement of fresh sewage through a full pipe from the dwelling to the land. Imitating the head of water pressure in the water-mains by a corresponding pressure of condensed air, he pretends to cause a regular steady flow of fresh sewage along full pipes, from the several districts of a town to a sewage outfall, and would thus render any formation of sewer gas simply impossible throughout his system of sewerage. Those of us who have paid much attention to expedients for reducing and keeping sewer-gas out of houses would thus find our occupation gone, and must acknowledge that "prevention is better than cure."

Leaving Mr. Shone to explain, with diagrams, the very simple and inexpensive details of his system, I will only add that, in order to prove his assertions, he has set up, at his own expense, a complete example on my farm at Wrexham, which is open to the inspection of all interested parties, and that I have witnessed for the last two months the regular intermittent lifting of crude sewage, at the rate of about 4,000 gallons per hour, to a height of nearly 40 feet, with an effective air pressure of nearly 18 lbs. to the square inch.

I am persuaded that compressed air, *not as a motive power*, as it is usually regarded, but *as a means of transmitting power from place to place*, has not hitherto received the attention it deserves, because, in the absence of Mr. Shone's invention, compressed air has usually needed a cylinder and piston to produce effective work at its point of application, and has consequently been debited with the friction and mechanical defects of such executive engines, in comparisons of the expense of steam and compressed air, each doing so many units of work.

This loss of useful effect has led to the common belief that compressed air is a most expensive power; but as Mr. Shone's diagrams will show you, his column of compressed air is simply an agent for the transmission of a steam engine's or a water-wheel's motive power to great distances with exceedingly little loss, and for exerting the motive power directly upon the surface of the fluid to be lifted, without involving piston or any frictional loss by machinery of any kind, on the spot where the lift takes place, such as would be required for doing the same work in any other manner.

The expenditure of power, in the shape of air compressed to the required number of lbs. per square inch, is just the equivalent in volume of the fluid lifted; and as experiments in mines and tunnelling works have amply demonstrated that this pressure of air can be extended for several miles with very little loss, at low pressures, it is evident that in many cases the compression may be effected by water power at almost nominal cost.

No engineer, who has had to collect at one spot the sewage of a town built upon undulating ground, can fail to see what an advantage he might derive from lifts of 20 to 40 feet applied, just where required in the manhole of a street, by a distant water-wheel, turbine, or steam-engine, from which mains of compressed air would radiate to those several man-holes containing Shone's "ejector."

The inventor goes further than this, and claims in a flat place such as Southport or Llandudno, to push the sewage along a sealed pipe, laid two or three feet below the surface throughout the town, and, if necessary, uphill, to an elevated sewage farm, or into the sea against the tide. The pipe would thus be always full of fresh sewage, driven along at a rate of not less than three feet per second. And, in such a case as that supposed, whenever one of the "ejectors" becomes full, it turns on the compressed air, and empty itself by its automatic arrangement misplaced; it is evident that a volume of sewage, equal to the full contents of an "ejector," will be discharged at the outfall, each time that one of these ingenious contrivances turns on the compressed air.

The sanitary advantages of this system are very striking, because increased fall can be given to the house drains and district sewers, emptying into an "ejector," and the temporary backing up of sewage in those contributory sewers, while the inlet valve of the ejector is closed during ejection, would give a very effective flushing on the next intermittent filling of the "ejector." This system would also most effectually sever each district from the sewage or sewer-gas of the rest of the town, by a constantly renewed water seal of some feet in thickness, and the exhaust air being led into a

gravitating sewer after each discharge would improve the sewer ventilation *pro tanto*.

I will not dwell further on this subject, except to remind any of my hearers who were present at the annual congress of the Sanitary Institute of Great Britain, held at Stafford in October last, that I there stated my belief that, if certain mechanical difficulties could be overcome in practice, the Stafford meeting would become conspicuous in the future, as that at which Mr. Shone's revolution in sewerage was first introduced to public notice. Since that time I have seen the new pneumatic system set to work with fewer hitches than are usually experienced with new inventions, in fact, I may say, with complete success, to the satisfaction of many experienced and practical engineers who have watched the trials from the first, and I would add that I never before knew crude sewage suffered to enter a pump without previous straining through a grating, but that all kinds of matter usually found in town sewage have freely passed through the ejector without causing any trouble with its valves.

[Mr. Isaac Shone, the Mayor of Wrexham, attended the Conference, but was unable to obtain an opportunity of explaining his Pneumatic Sewerage System. He will be glad to show the system in operation at Wrexham, to anyone interested in the subject.]

MISCELLANEOUS.

OLD LONDON WATER SUPPLY.

London is naturally so well situated for purposes of water supply, owing to the numerous springs and watercourses on all sides of it, that no need for artificial means of supply appears to have been felt before the thirteenth century. The monk, Fitz Stephen, who wrote at the end of the twelfth century, describes these springs as "sweet, salubrious, and clear," but as London increased, the wells decayed and the streams were fouled. According to Stow, the first conduit erected in the City of London was that in Westcheap (now Cheapside), and the water with which it was supplied was brought from Paddington. The building of this was commenced in the year 1235, but it was not completed until 1285. The cost of laying the water-pipes being found to be heavy, the several Lord Mayors invited the principal citizens to contribute, and in 1235 some foreign merchants, being desirous of landing and housing wood, &c., purchased the privilege they desired by a yearly payment of fifty marks, and the donation of one hundred pounds towards the expense of bringing water in a six-inch leaden pipe from Tyburn to the City. The various springs of the district which fed the Tye-bourne were gathered together in a reservoir on the spot where Stratford-place now stands. In course of time the reservoir was arched over, and a banqueting house was erected upon the arches, where the Lord Mayor and Corporation feasted when they annually visited the reservoirs and hunted the hare or the fox in the fields of Marylebone. The banqueting house was pulled down in the year 1737, and in course of time the existence of the cisterns was generally forgotten. Early in the present century some of the arches were broken, after a flood which caused the inundation of the lower part of one of the houses in Stratford-place, and in 1875 the subterranean chambers were discovered by workmen engaged in laying wood pavement in Oxford-street.

Besides such sources of water supply as the springs and bournes afforded, there were always present the abundant stores of the river. The citizens fetched the water for their use from the Thames, but the dwellers in the lanes that led to the water-side in course of time stopped the passage, and would only let those pass who paid a duty. Great complaints arose on all sides respecting this grievance, and in 1342 an inquisition was made, and persons were sworn to inquire respecting the annoyances and stoppages in the several wards.

Much was done in the 15th century by the authorities of the City in the laying of leaden pipes, and the erection of new conduits. In 1439, the Abbot of Westminster granted to Robert Large, the Lord Mayor, and the citizens of London, and their successors, one head of water containing twenty-six perches in length and one in breadth, together with all the springs in the Manor of Paddington, for an annual payment of two peppercorns.

In the sixteenth century, serious apprehension was felt owing to the scarceness caused by the increase in the number of the inhabitants and the drying up of the springs. It, therefore, became necessary to seek new sources of supply, and these were found in the neighbourhood of Hampstead-heath, Hackney, and Muswell-hill. An Act of Parliament, applied for by the Corporation, in 1544, for the purpose of rendering these springs subservient to the supply of the north-western portion of the City, was passed, but in spite of the urgent need of this supply, which is expressed in the preamble of the Act, the scheme was not carried out until the year 1590, when another important source of supply had been obtained.

In 1568 a conduit was constructed at Dowgate for the purpose of obtaining water from the Thames, but this was only doing on a small scale what was soon to be done on a large one. In 1580 Peter Morice, an ingenious Dutchman, brought his scheme for raising the Thames water high enough to supply the upper parts of the City under the notice of the Lord Mayor and Aldermen, and in order to show its feasibility he threw a jet of water over the steeple of St. Magnus Church. A lease for 500 years of the Thames water, and the places where his mills stood, and of one of the arches of London-bridge was granted to Morice, and the waterworks founded by him remained until the begining of the present century. There were some difficulties at the outset as appears by certain papers indexed in the City *Remembrancia*.* In July, 1580, the Lords of the Council wrote to the Lord Mayor desiring him to carry out the agreement with Morice, and from a letter written by the Lord Mayor to the Lord Chancellor (December, 1582), it appears that some natural irritation of the water-bearers, who thought their trade would be injured by the supply of water to the houses of the citizens, had to be smoothed over. It was found that these men would still have as much work as they were able to perform in drawing from the conduits. About the same time as Morice propounded his scheme for utilising the water of the Thames, we learn from Stow, that a man named Russel proposed to bring water into London from Isleworth. In 1591, an Italian, named Frederick Genebelli, proposed to cleanse the filthy ditches in and about the City, such as the Fleet river, Houndsditch, &c., and to bring plenty of wholesome, clear water into the City through them, but it does not appear that his scheme was entertained. In 1606, nearly £20,000 was expended in scouring the River Fleet, which was kept open for the purposes of navigation as high as Holborn-bridge.

Another attempt was made in 1594 to supply a

* Analytical Index to the series of Records known as the *Remembrancia*, preserved among the Archives of the City of London. London: 1878.

portion of the City with water from the Thames, and Bevil Bulmar erected a large horse engine at Broken-wharf, near where Blackfriars-bridge was afterwards built, for the purpose. An Act for bringing water by means of engines from Hackney marsh to supply the City of London with water passed in 1609, the profits of which undertaking were to go to the College of Polemical Divines, founded by Dr. Sutcliffe, at Chelsea, but about this time a much more important scheme was projected.

At the end of the reign of Elizabeth, the Corporation obtained an Act of Parliament to empower them to cut a river, for conveying water to the City, from any part of Middlesex or Hertfordshire, but nothing was done in this direction until after the accession of James I. to the throne. In 1605 and 1606, Acts of Parliament were passed which gave the Corporation power to bring water from the springs of Chadwell and Amwell to the northern parts of the City, and, the Corporation not being inclined to carry on the matter, they transferred their power, in 1609, to Hugh (afterwards Sir Hugh) Middleton, citizen and goldsmith, who entered into the vast scheme with characteristic energy. On September 29th, 1613, the New River was opened, and London was amply supplied with water for many subsequent years.

The *Remembrancia*, which has been already noticed, contains some curious particulars respecting the applications made by various noblemen to be allowed to have pipes of the size of a goose quill attached to the City pipes for the purpose of supplying their houses with water. In 1592 Lord Cobham applied to the Lord Mayor for a quill of water from the conduit at Ludgate to his house in Blackfriars, but the consideration of the request was postponed, and in 1594 Lord Burghley wrote to the Lord Mayor and Aldermen in support of Lord Cobham's application. Lady Essex and Lady Walsingham asked for a supply of water for Essex-house in 1601, and obtained the Lord Chamberlain's (Earl of Suffolk) influence to further their suit, but on June 8th, 1608, the Lord Mayor wrote to Lord Suffolk that the water in the conduits had become so low, and the poor were so clamorous on account of the dearth, that it became necessary to cut off several of the quills. "Moreover," he added, "complaints had been made of the extraordinary waste of water in Essex-house, it being taken out not only for dressing meat, but for the laundry, the stable, and other offices, which might be otherwise served." As London extended itself westward, and the City came to join Westminster, the drain must have been great upon the water supply, which was originally intended for a considerably smaller area. In 1613, Lord Fenton applied for a quill of water for his house at Charing-cross, but the Lord Mayor refused to grant the request on the ground that the conduits did not supply sufficient water for the City. Sir Francis Bacon (afterwards the great Lord Verulam) asked, in 1617, for a lead pipe to supply York-house, and Alice, Countess of Derby, requested to be allowed a quill of water in the following year. This celebrated lady, afterwards married to Lord Chancellor Ellesmere, lived in St. Martin's-lane, and we learn from the City letter-book (quoted in the Index to the *Remembrancia*) the amount of water supplied to her was at the rate of three gallons an hour. In subsequent years, we notice among the applicants for quills of water the celebrated names of Sir Harry Vane, Denzell Holles, the Dukes of Albemarle and Buckingham, and the Earl of Northumberland.

In the seventeenth century various schemes for the better supply of the now largely extended London were proposed, amongst them was the plan of a Mr. Ford for bringing a navigable canal from Rickmansworth, in Hertfordshire, to St. Giles's-in-the-Fields. An opposition scheme was that of Sir Walter Roberts, who proposed to convey water from Hoddesdon, in Hertfordshire, to Islington in a closed aqueduct of brick or stone. In the Act for rebuilding the City after the great fire, it was provided that Thomas Morris (a descendant of Peter Morice, who commenced the waterworks at London-bridge) should have power to rebuild with timber his water-house for supplying the City. The works continued in the family until 1701, when they were sold for £38,000 to Richard Soames, and afterwards became the property of a company. In 1767 the fifth arch of the bridge was granted for the use of the company, and in 1822 the Acts relating to it were repealed. In 1691 waterworks were constructed at the bottom of Villiers-street, Strand, for the supply of a part of Westminster. The projectors were incorporated by Act of Parliament under the designation of "The Governor and Company of Undertakers for Raising Thames Water in York-buildings." The tower erected by this company long remained a striking feature in views of the left bank of the Thames.

In conclusion, it is not necessary to do more than give the dates of formation of the various water companies previous to the Commission of 1828. The Chelsea Waterworks Company for supplying Westminster with Thames water was formed in 1723, the Lambeth Company for supplying districts south of the river in 1785, the Vauxhall Company in 1805, the West Middlesex Company in 1806, the East London Company in the same year, the Grand Junction Company in 1811. The immense influence which the formation of these companies exerted on the growth of London has been pointed out by Professor Prestwich, in his address before the Geological Society in 1872. The direction in which London originally grew was influenced by the formation of the bed of gravel. Eastward it extended towards Whitechapel, Bow, and Stepney; north-eastward, towards Hackney, Clapton, and Newington; westward, towards Kensington and Chelsea; northward, it came to an abrupt termination at Bloomsbury and Clerkenwell. The clay districts of Holloway, Camden-town, Regent's-park, St. John's-wood, Westbourne, and Notting-hill, could not be built upon until water was supplied by the great water companies.

AILANTHUS SILK.

The *Times* gives the following account of the acclimatisation of the Ailanthus silkworm:—

For a long time the mulberry silkworm has been the sole producer of silk known in Europe, and no other species has been able to rival it for the beauty of the silky staple of its cocoon. But now, after more than 30 years' persistent epidemics, it is really at a loss that European producers attempt to maintain here and there, without any certainty for the following year, a few silkworm nurseries. Commerce seeks in China and Japan, where labour is so cheap, the greater portion of the silks used for weaving. These silks, however, are of inferior quality, the peoples of the extreme East keeping with jealous care their finest products for home use. Thus our silk stuffs are no longer the magnificent tissues which were the glory of French manufactories, and we may see every day in the shop windows cheap stuffs that have far more "dressing" than silk. In these circumstances French manufacturers have been looking about to discover if no substitute exists for the time-honoured mulberry silkworm. For about a dozen years an imported moth has become a French insect, living in a free state and effecting its reproduction without any interference on the part of man. On the other hand, there is necessary for the rearing of ordinary silkworm, the purchase of healthy eggs, a nursery, and mulberry trees, implying expenses which lead to a great loss if the rearing is a failure. Many persons may have observed flying about in the evening in the month of June, in the squares, avenues, and gardens with ailanto plants in the neighbourhood of Paris, and even in Paris itself, a large moth, with wings variegated by longitudinal

bands. In winter, there may be seen hanging to the leafless branches long cocoons, of a pretty pearly gray. These are the work of the caterpillar of *Attacus cynthia*, or ailanto silkworm, introduced into France by the Acclimatisation Society, under the direction of M. Guerin-Méneville. The moth is now as much at home in France as in its native habitats, as robust, as large, and as well-coloured as in the north of India and China. No great welcome has hitherto been given to the new comer in France. The cocoon is not very rich in silk, it is strongly incrusted, and, on this account, presents difficulties in weaving, being regarded as good only for producing floss silk—a material of little value. Attempts have been made to wind it; but the winding yields only the single thread of the cocoon—too fine to be used, and requiring special and expensive machinery. This question has now, however, been taken up and solved by M. le Doux. He has succeeded to some extent in separating the gum from the silk, permitting the threads to be drawn with great ease, and preserving to them, at the same time, sufficient natural glue to admit of the threads of several cocoons wound at the same time being, by the operation of twilling, twisted together and giving strands of raw silk, the only kind that can be utilised in weaving. Another chief point in the discovery of M. le Doux is that this production of raw silk is obtained with the same pans and the same hand processes as ordinary raw silk, so that no objection can now be raised on the score of expense. The specimens of silk produced are of a pretty blonde colour, and make charming stuffs of *écru* colour. Moreover, both French and English dyers will know how to give the silk a variety of colours. The rearing of this new silkworm requires neither care nor expense. The wild moths look after themselves, and it only remains to collect the cocoons attached to the leaves or small branches. The ailanto tree of Japan, on which the worm feeds, is of rapid growth, and admirably adapted for covering waste spaces.

AMERICAN HONEY.

Bee-keeping is a regular branch of industry in the United States, and it is stated that over 35,000,000 lb. of honey are there produced and sold annually. The tendency in this, as in other occupations, has been for the trade to be carried on by persons having large capitals. The bee-keepers have frequently from 2,300 to 5,000 swarms of bees, and some far larger numbers. Messrs. Thurber and Co., of New York, for instance, have about 12,000 swarms of bees. Of course, it is only by a thorough organisation that such large numbers of these little workers, who toil without pay, can be looked after and cared for. The system in the United States is to farm out the swarms. Arrangements are made with farmers and those who own orchards, in suitable localities to allow an apiary of perhaps a hundred swarms to be placed in their grounds. At a distance of three or four miles another apiary will be placed with some other farmer. For this accommodation either a fixed rent or a share of the honey produced is paid, and the bee-owner sends expert workmen to clean the hives, to take out the boxes of surplus honey as they are filled, and to destroy the moths, grubs, and other creatures that take advantage of the bees' frugality. As showing the lucrative character of this business it is said that a firm of shippers paid to one bee-keeper for his season's crop of honey a sum larger than the salary of the President of the United States. It is estimated that on an average one acre will support 25 swarms of bees, and as the yield of a swarm is generally about 50 lb. of honey, it is evident that this trade may yet be developed. Already the firm above mentioned, in addition to a corps of experienced bee-men to tend the hives, find occupation for nine men and two steam saws during five weeks of the year in cutting up the timber for the 72,000 boxes used to hold the comb honey. The glassmakers also find some custom from the honey dealers, 144,000 panes of glass being required to make the slides and ends of boxes. Much attention has been paid in the United States to the improvement of the breed of bees, and queen bees have been imported from Italy, Cyprus, and elsewhere for the purpose of improving the stock. Some years ago fine Italian queen bees were sold for as much as £10 each in New York, but by forming nurseries and rearing queens carefully selected from fine broods, queens of good blood, if a term may be borrowed from the turf, may now be bought at prices ranging from 1 dollar to 5 dollars each. Side by side with improvements in the culture of the bee, too, there have been many ingenious contrivances in order to save the labour of the bees and of the honey dealers. About ten years ago a German suggested that thin corrugated sheets of wax, which he called "Artificial tablets," should be provided for the bees to make their comb from. These, however, did not come into general use, but a few years ago Mr. W. M. Hoge effected an improvement by starting the side walls of the cells. When these "foundations," as they are called, were presented to the bees, the intelligent little creatures at once took advantage of them and extended the side walls so as to form the regular hexagonal cell. The machine by which the impression is made on both sides of the wax is very simple, and somewhat resembles a clothes-wringing machine, only the iron rollers are studded with little hexagonal-headed pins just the size of the section of a cell, so that, when the thin sheet of wax is pressed up between the pegs to the height of about 1-16th of an inch, it offers a substance for the construction of the cell walls. Another remarkable adaptation of machinery is afforded by the use of a rotating frame, which causes the cells of the comb placed in it to be emptied by centrifugal force. The empty, uninjured comb is afterwards replaced in the hive, and again used by the bees. As about three-fourths of the time of the bees, it has been computed, is taken up in the construction of the comb, it will be seen that by these contrivances a great saving of bee labour is effected.—*The Times.*

CINCHONA CULTIVATION IN BENGAL.

It appears by the report of Dr. King, the superintendent of the Royal Botanic Garden, Calcutta, on the Government cinchona plantation in British Sikkim, for the year 1878-79, that the operations in the plantation have been greatly retarded by the unusual drought of the cold season, which caused the death of a number of old trees, and prevented the planting out of young ones. The total number of cinchona plants of all varieties planted out at the close of the year was 4,028,055, of which 3,589,965 were of red bark species. As 278,958 lbs. of bark remained in the hands of Mr. C. H. Wood, the Government Quinologist, at the close of the year 1877-8, it was not thought desirable to collect more bark crop than was necessary to meet the requirements of the febrifuge factory. Only 261,695 lbs. were therefore taken, namely, 13,967 lbs. of yellow bark, 812 lbs. of grey bark, and 246,880 lbs. of red bark. The crop was taken by one of the three methods of harvesting, viz., uprooting, coppicing, and thinning, thus:—

	lbs.
Uprooting	52,484
Coppicing	14,464
Thinning	194,711
Total	261,659

The continuous increase in the amount of cinchona febrifuge manufactured by the Quinologist is very marked; thus the out-turn in the year 1874-75 was only

48 lb. 10 oz., in 1875-76 1,040 lb. 6 oz., while that in 1878-79 was raised to 7,007 lbs.

A reduction has been made in the cost of production, which has resulted partly from the increased scale of manufacture, and partly from the introduction of improvements in the process, whereby an increased yield of alkaloid from the bark has been obtained. The nett profit on the manufacture is 42,412 rupees, and as the total amount of capital, with interest at 4 per cent., which has been sunk in the cinchona plantations and in the manufactory is approximately 10 lakhs of rupees, the receipts for the last year, after paying all expenses, yielded interest of about $4\frac{1}{4}$ per cent. on the capital outlay. During the past year, experiments have been in progress on the manufacture of pure sulphate of quinine from the calisaya bark yielded by the plantations. Experiments have also been conducted on the economy of preparing pure alkaloids from the succirubra bark.

AN ELECTRIC RAILWAY.

Some particulars respecting the electric railway which has been in operation at the Berlin Industrial Exhibition are given in the *Archiv für Post und Telegraphe*, from which it appears that this new exemplification of the application of electricity as a motive-power sprang from a question addressed by Herr Westphal, a master builder of Cottbus, near Berlin, as to the possibility of utilising the force generated by coal burnt at that village by transmitting it to Berlin. The problem ultimately resolved itself into the question how far electric force could be employed as a motive-power on rails. The experiments which were instituted were successful, and led to the construction of the electric railway, as it has been seen in operation in the Berlin Exhibition. The arrangement is as follows:—There are two lines of rails laid down, which, in a narrow-gauge line, return into themselves in a ring shaped curve. The length is about 300 mètres. In the middle is an isolated third line, consisting of an upright, continuous iron plate. The locomotive carries two rollers, with which it stands in connexion with the isolated middle line. The essential portion of the locomotive is formed by an electro-dynamical machine, one pole of which is connected with the middle line and the other with the pair of outer rails, through the outer wheels. Similarly the machine which produces the current stands in the machine-room in connection through one pole with the middle line, and through the other pole with the outer pair of rails. When, therefore, the dynamical machine in the locomotive is on the railway, the electric current produced in the machine soon runs through it and causes it to rotate and to impart its rotatory motion to the wheels of the locomotive, and the latter continues to move until the current is interrupted. Even an imperfect state of isolation on the part of the rails does not materially affect the action of the machine. When the locomotive is moving its conducting wires form much better conductors than the damp earth. If the current is interrupted, the damp ground is not a sufficient conductor to keep the dynamo-electrical action going. The magnetism of the machines producing the current consequently disappears, and the result is that the subordinate stream through the earth is also interrupted. A great advantage is possessed by the transmission of electric force from the fact that the locomotive, whether moving slowly or quickly, always works up to its full power—an effect which has hitherto been an unsolved problem in mechanics. When the machine that gives the power has to do much work and so goes slowly, the counter-currents it produces are also correspondingly weak, and the current through the conductors thereby undergoes an increase in strength to a similar extent. By this mean the electro-magnetism and, corresponding to this, the attractive power of the machine are increased. The dynamo-electric locomotive has the further advantage that it carries in itself the power which can be employed as a brake, inasmuch as it becomes itself the primary or current-producing machine when it rotates more rapidly than the actual machine. In judging of the performances of the electric locomotive in the Berlin Exhibition, it must be remembered that it was not constructed for the purpose to which it has been applied—that is, to propel the three elegant little passenger carriages which are attached to it. Each carriage holds from 18 to 20 persons, and all three are drawn in from one to two minutes round the circular railway of 300 mètres in length. The locomotive was originally made for the purpose of drawing up coals out of the pit.

THE BROOKS UNDERGROUND TELEGRAPH CABLE.

A new system of insulating underground telegraph wires has recently been experimented on by the Silvertown Telegraph Company. It is the invention of Mr. Brooks, an American, and differs from all others in the fact that the material employed for maintaining the insulation of the line is a liquid—paraffin oil—which is known to possess, for this purpose, qualities of the highest order; and in laying it the wires—thirty, forty, or fifty, as may be required—covered with cotton binding, are placed in an iron pipe, conveniently located, and the pipe line filled with oil—allowed to run in until full, the maintenance of the supply being assured by providing an elevated vessel of the material at intervals, so that a constant pressure will be kept within the pipe. All qualities of oils do not answer for this purpose, and there was great difficulty in finding the right kind of oil. In testing this wire, it is found that the oil electrifies to a much greater extent than any known insulator. The specific electrostatic capacity is extremely low. Tests made in America show it to be one twenty-seventh of that of ordinary gutta-percha. This, as all electricians know, is a great point in its favour for underground wires. There are several lengths laid and at work in and near Philadelphia.

CORRESPONDENCE.

LONDON WATER-RATES.

The public at large has, indeed, every reason to be grateful to the Society of Arts for its continued efforts to secure a more plentiful supply of water, and at a more reasonable rate than the one imposed at present by the New River Company. I do not see that any special merit is due for any alleged improvement, either in the quality or the quantity. The consumers and water-rate payers had a right to expect every consideration. It was to the interest of the companies to be liberal with their customers. As I think my experience is indicative of the peculiar system of rates imposed by the water companies, I submit the facts for your information. When I returned to London, after a residence abroad for some years, I purchased the 1843 lease of the house I occupy. The ground-rent, for the Duke of Norfolk, was £50 per annum, I, of course, being bound by the covenants for repairs, besides having to pay a large sum before taking possession. The parochial rates were calculated at £43 per annum. My water-rate for years was 30s. per annum. Now the parochial rating has been raised from £43 to £63 per annum, and as this is the basis on which water-rate is charged, I now pay £4 0s. 6d. per annum. The other local rates are, of course, proportionately increased.

Now, we are only two in family, and the consumption of water is now much less than in former years, for the simple reason that we do not have visitors staying with us as at a previous period. The value of the house is not one farthing more to me than it was when I took the lease. As a man of letters, and as a journalist, I occupy and use my premises. There is no prospective value, even if I now tried to sell the lease for the ten years it has to run. I took the house on economical grounds, and I have been quite defeated in my calculation as to the amount I could yearly afford for house rent, local taxes, &c.

Thus, without having the smallest increase of accommodation, without having any additional supply of water (less, in point of fact, at the present time), without deriving any advantage whatever of increase for estimated value of the house, every year I find the local outlay larger and larger. A beneficial lease might justify the additional charges, but my contention is that such is not my case, for the liability for repairs renders the landlord's ground-rent quite high enough in a street now filled with hotels and boarding houses, instead of being inhabited, as in the first case, by private persons.

C. L. GRUNEISEN.

16, Surrey-street, Strand, W.C.

CAST-IRON MAGNETS.

I see in your issue of August 22, an experiment of Mr. Chesnoff for making cast-iron magnets. I have pleasure in stating that cast-iron magnets date back to October 22, 1851, when my father, Dr. Hearder, read a paper at the Polytechnic Institution, at Falmouth, and exhibited one of his own plan, which was very powerful. A committee were told off to test it, consisting of R. W. Fox, Esq., F.R.S., W. M. Tweedy, Esq., Dr. Jago, Dr. Vigors, and the Secretary, a printed report of which I have, and also the same magnet, which is as strong as ever. I have made scores since on the same plan.

WM. HEARDER.

Plymouth.

GENERAL NOTES.

Temperature of Town Water Supplies.—A paper was read on this subject at the recent meeting of the British Association by Mr. Baldwin Latham, in which attention was drawn to the fact that the temperature of the water-supply of a town, as furnished by public waterworks, was totally independent of the temperature of the water at its source of supply, and that invariably the temperature of the water is the temperature of the ground at any season of the year at the depth at which the distributing mains were laid. The average temperatures throughout the year, whatever the source or mode of supply, varied very little, but there was great difference in the range of temperature, and that while temperature in the chalk wells at Croydon gave an average monthly range, based upon daily observations, of 0·64°, the same water when supplied direct from the mains, gave an average monthly range of 21·14°, or when stored in a cistern a range of 28·05°; while water supplied from the Thames in Westminster gave an average monthly range of 24·69°, but the average yearly difference of temperature between the chalk water supplied at Croydon and the Thames water supplied in Westminster was only 0·67°.

Artesian Wells in Central Australia.—Successful borings for water have been made in Frome County, South Australia, in a district hitherto almost devoid of surface water, and regarded as consequently almost worthless for agricultural or pastoral purposes. One well, sunk in some arid country near Lake Frome, at a distance of 400 miles north of Adelaide, as the crow flies, which has been bored to the depth of 370 feet, produces a daily supply of 10,000 gallons of excellent water; and other artesian wells in the same district have proved equally successful. As the result of the enterprise, we are told that, whereas that country would formerly only carry a few thousand head of stock, its capabilities are now practically unlimited. This success will stimulate similar enterprise elsewhere. Much of the so-called desert country forming the boundary between the coast districts and the rich pastoral lands which have been discovered in the interior of the continent will be reclaimed by this means. The South Australian Government is sending a scientific expedition to the shores of the Great Australian Bight, with a view to the selection of proper sites for artesian wells to tap the deep springs which are known to exist there; so that a part of the country which has hitherto been regarded as almost the most inhospitable portion of Australia will, by this means, says the *Colonies and India*, be thrown open to agricultural enterprise.

Trade with Africa.—The following statistics connected with this subject are taken from a letter by Mr. James Bradshaw, printed in the *Manchester Examiner*:—"The cost of conveying a ton weight of English manufactures from the East Coast of Africa to Lake Victoria Nyanza (500 miles) is at least £150. A light narrow gauge railway made at a cost of £2,000 per mile, would convey over this distance a ton weight for £5 6s., besides opening a new trade with 50,000,000 of people in the regions reached through this suggested railway. The efforts of chambers of commerce directed to secure cheap transit in this one small portion of Africa would more effectually relieve English industries in two years than 20 years' supplication to the civilised world to abandon those troublesome tariffs. I believe the population of Africa is nearer 400,000,000 than 200,000,000. To get at the heart of the country £2,000,000 sterling are required at once, and to develop the whole continent £10,000,000 will ultimately be needed. Forty-six years ago £20,000,000 sterling were paid out of the national purse to compensate a handful of West Indian sugar planters for the loss of a comparatively small number of slaves who received their freedom by the abolition of slavery in 1833. How infinitely greater the issues involved in the expenditure of £10,000,000 for commercial purposes. First, a return is expected on the money; secondly, the redemption of a whole continent, morally and physically, from savagery; thirdly, securing the commercial future of England, and all the sequences for a century to come at least.

Gold in Russia.—The St. Petersburg papers report a great development of the gold production of Russia. Strata containing gold in considerable quantity have recently been discovered in the Ural Mountains. It is said that in the district of Sennigsei, a Russian proprietor has found in his gold mine, near Motygynn, a nugget 445 lb. in weight, representing a value of nearly £15,000.

NOTICES.

GROSVENOR HOUSE.

The Duke of Westminster is desirous that designers, artisans, and the like, employed in any branch of Art applied to productive industry, should have the opportunity of inspecting Grosvenor House, with its Works of Art, daily, including Sundays, during the months of August and September, 1879, from 2 p.m. to 6 p.m. He regrets that, for want of room, he cannot extend the admission beyond the persons specified.

A number of tickets of admission have been placed in the hands of the Secretary of the Society, for distribution among persons answering to the above description.

Such persons can obtain tickets on application at the Society's house, by bringing with them a paper containing their names, addresses, and occupations.

Each ticket admits a party of four.

There will be no admission on wet afternoons.

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FRIDAY, SEPTEMBER 12, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

PROTECTION OF SHIPS FROM LOSS BY FIRE AND FROM LOSS BY SINKING.

Committee.—Thomas Brassey, M.P., B. Francis Cobb, Lord Alfred Churchill (Chairman of the Council), Rear-Admiral Nolloth, Captain Price, R.N., M.P., Admiral A. P. Ryder (Chairman of the Committee), Captain Henry Toynbee, F.R.G.S., F.R.A.S.

The Fothergill Gold Medal is offered for the best means of attaining the two above-mentioned combined objects. A Silver Medal will be given for the best means of protecting ships from fire. A Silver Medal will be given for the best means of protecting ships from sinking. The receiver of the first Silver Medal may receive also the second, if the means proposed be deemed the best for each of the two objects considered apart from the other, although not deemed the best means of attaining the two objects combined—to which alone will the Gold Medal be awarded. The following are the conditions of this offer:—

Protection of Ships from Sinking, after Collision, after Touching the Ground, &c.—Silver Medal.—The Society of Arts offer their Silver Medal for the best means of preventing a ship from sinking, after collision, after touching the ground, or from any other cause; or for delaying sinking as long as possible by—

I.—Structural arrangements.
II.—Appliances, non-structural.

1. Preference will be given to structural arrangements which occupy the least amount of valuable space, and interfere least with the stowage of important articles.

2. Preference will be given to appliances which are least unsightly, the most ready to hand, and require least "fitting" for immediate use.

3. Preference will be given to structural arrangements least obstructive to free ventilation.

4. Preference will be given to structural arrangements least expensive, as to first cost and repair.

5. Preference will be given to appliances which are least expensive, which occupy least space, which are least liable to injury, and which are most trustworthy.

Competitors are at liberty to draw a distinction between structural arrangements and appliances most suitable to men-of-war, to passenger ships, to ordinary merchant ships; also between the different circumstances attending accidents by day and accidents by night.

Protection of Ships from Fire.—Silver Medal.—The Society of Arts offer their Silver Medal for the best means of preventing or extinguishing fire on board ships by—

I. Structural arrangements for preventing fire.
II. Structural arrangements for aiding in the extinction of fire.
III. Appliances for extinguishing fire.

1. Preference will be given to structural arrangements which occupy least amount of valuable space, and interfere least with the stowage of important articles.

2. Preference will be given to appliances which are least unsightly, the most ready to hand, and require least "fitting" for immediate use.

3. Preference will be given to structural arrangements least obstructive to free ventilation.

4. Preference will be given to structural arrangements least expensive, as to first cost and annual repair.

5. Preference will be given to appliances which are least expensive, which occupy least space, which are least liable to injury, and which are most trustworthy.

Competitors are at liberty to draw a distinction between structural arrangements and appliances most suitable to men-of-war, to passenger ships, to ordinary merchant ships; also between the different circumstances attending a sudden alarm of fire by day, and sudden alarm by night.

Models or drawings of structural arrangements and of appliances must be sent in not later than the 1st of January, 1880, addressed to the Secretary, Society of Arts, John-street, Adelphi, London, W.C., and must in every case be accompanied by a short description.

The Council is at liberty to withhold the Medals if, in the opinion of the Committee, nothing is submitted worthy of the award.

(By order,)

H. Trueman Wood, *Secretary.*

August, 1879.

HEALTH AND SEWAGE OF TOWNS.

THE DOUBLE CHECK SYSTEM OF HOUSE DRAINAGE.

By Henry Masters.

Upon reviewing the various systems of house drainage that have been brought before the public during the past dozen years, I have been struck with the absence of simplicity in many of the schemes propounded. One school of sanitarians consider special-made traps essential. Another, the absolute necessity of mechanical contrivances for pumping up, or extracting the foul air from drains, though each agree that drain ventilation is necessary.

Nearly all the schemes put forward advocate up-currents of air by single pipes, and pumping terminations; some admitting air near the ground, and some not. If the multiplicity of special pipe terminations be evidence, down draft is a very formidable thing to contend with. In my scheme, I am a great friend to down draft, I advocate and encourage it in every possible manner, and the more I get of it the better. I, therefore, differ in this particular from other sanitarians.

In my early practice, as an architect and surveyor, the correct thing was to trap every closet, sink, and outlet; also, to put traps at the foot of every soil and rainwater pipe, and the over-flows of tanks, the great object being to hermetically seal, so far as possible, every drain and soil pipe; the latter was made tight at top and bottom, and the former at either end. The same principle of tight work was applied to our common sewers, and I regret that we have still advocates for sealing, both as regards the sewers of our towns, and also our private drains.

Upon applying my double-check system of house drainage, I always avoid using any speciality or mechanical contrivance. All the details required may be purchased at ordinary dealers in sanitary ware and ironmongers. I use, generally, the common form of trap, ordinary glazed ware pipes (sometimes with Sandford's joints), and stout cast-iron soil and air pipes, selecting only careful and well-proved men for doing the work. My experience having taught me that simplicity is the best engineering, and the fewer parts the better, I decidedly object to any mechanical valves or revolving terminations.

As an example of simplicity of house drainage, and as a system which could never get out of repair, although we have, upon referring to the past, but few examples left us of the sanitary arrangements of our mediæval forefathers, I cannot refrain from bringing before you one such example of a well-arranged and ventilated system of domestic drainage, as applied to the hospital of St. Cross, Hampshire.

The architect of St. Cross, in common with the forethought that governed our forefathers in the selection of suitable sites for their religious and domestic buildings, took care that abundance of water, and facilities for drainage, should be secured. In the case of St. Cross, the water from the River Itchin is higher above the hospital than below; advantage was taken of this circumstance to make a culvert from the higher part in the direction of the building, and in the garden was constructed an open pond, through which the water flowed, and was the source of the domestic supply. It then passed on and round the brethren's dwellings, and under a foot-bridge, constructed for the double purpose of communication with the garden, and for throwing over waste from the cooking department. The water passed on under several projecting wings of the building, in which were placed the closets, four in each wing, two up stairs and two down. In the domestic arrangements of St. Cross, each brother had a complete suite of apartments. They were provided with a sitting-room and a bed-room, and also a scullery, where they washed, and from the sculleries were approached closets, one to each dwelling in the wings referred to, and here we have a perfect system of ventilated drains and open soil pipes, the former an open channel formed by the river-water being diverted, and the latter a shaft, about a yard square, extending from a short distance of the running water to the seat, by which the soil passed directly into the water, air being freely admitted to the soil trunk, and passing out through the seats and open windows of the closets.

I admit that the system adopted by the Brethren at St. Cross would be hardly applicable to our modern views, but we can take a lesson from the works of these ancient men. Their sewers, as well as their soil-shafts, were open from end to end, and they avoided the complication of traps and cowls.

Unfortunately, in our cities, we are driven by circumstances to use close drains to some extent, and I hardly think we are prepared to advocate open channels for our sewage, through the middle of our streets, or open shafts for our closets; and, without expressing any opinion what others have done with special traps and cowls, I will describe a scheme I have applied during many years of my architectural practice, and in every case have found it effective.

The scheme I advocate for house drainage I have designated "The Double Check System," because I apply a double trap and a double air-pipe, using three pipes altogether. Branches from the closets inside pass through the external walls, and join the soil-pipe, which is extended above the roof and clear of all windows; the curved termination of this pipe points in the direction of the house front. Where the drain passes out from the front of the house an air-pipe is connected; this also extends above the roof, the curved end pointing in the reverse direction to the soil-pipe termination.

Houses that are connected together are much more difficult to drain than when detached; my selected examples, as shown by the drawings exhibited, are from houses in rows. If the houses are detached, I invariably put all drains outside the walls, and cut off all waste pipes, I also ventilate all the drains as described.

The double check system, in its most simple form of application, consists of a pipe drain from the back to the front of the house, if in a row, or outside the house if detached; at the back of the house, it is joined to the vertical soil-pipe, to which are connected the w.c. pans. This soil pipe extends its full size above the roof, and has a curved termination, pointing from the house (say to the right). At a point of the pipe drain outside the front of the house is connected a large iron air pipe extending above the roof; this air pipe has also a

curved termination, the same as upon the soil pipe extension, but it points in a reverse direction, or from the front of the house (say to the left); thus we have a U-shaped arrangement, an open pipe at the front of the house, with a left-hand curve, an open pipe at the back of the house with a right-hand curve, the lower ends of each pipe connected with the drain.

The foregoing explanations have reference to the house-drains proper, but unless accompanied by some arrangement for cutting off the public sewers from the house drains, the system would become a "public sewer ventilator," and to ventilate the public sewers at private expense, or to assist in establishing a current of sewer gas in the direction of the house would be alike opposed to my views. I have, therefore, arranged a double trap for this purpose.

There is no speciality in this trap. It is simply two common syphon traps (as known in the building trade by that name), connected together by a short junction pipe, to which is attached a large iron gas exit or escape pipe, extending above the house roof. The action of this double check sewer gas trap is as follows:—Upon such occasions as a pressure of gas present in the public sewers, capable of exerting sufficient force to pass a water trap, a portion of such gas will be forced into the house drain, and passing the first trap (which acts as a safety valve), it will meet with resistance at the second trap, but, meeting with no further hindrance, will pass up the large gas exit pipe, and so escape into the air above the house roof. Sewer gas, therefore, either by being forced through the water of the first syphon trap, or being absorbed by the trap water, is prevented from passing into the house drains by a barrier, viz., the second syphon trap, which, in an occupied house, would be always charged with water. If pressure existed, it would be released as soon as the first trap is passed, because it would have a large pipe provided for its escape freely into the air, and above the roof.

The tops of all pipes are protected with terminations, the capacity of the air-ways being equal to the area of pipe. I object to any mechanical terminal, preferring only such contrivances that cannot get out of order, and that may be procured easily, and which will prevent birds making their nests in the pipes.

In order that any system of house drains be perfect, it is absolutely necessary that facilities should be given, so that any accumulation of impure air in the drain or soil-pipes should be made to periodically "move on" and finally be expelled. All house drains and soil pipes become somewhat foul in the course of time, and if I were to introduce an old soil-pipe into this room, you would, I am sure, object to be in its company. Many old soil-pipes have been found to be thickly lined with very disagreeable substances, giving off the most unpleasant scents, especially when in a damp state, and during hot, calm weather; and we all know the very unpleasant odour prevailing in many of our houses after the cooking of cabbage. These emanations should be got rid of as soon as possible.

In my experience of revolving cowls, which make one believe (during their revolutions) they are doing some good, I have found that at the time they are most required they are at a stand still, and act as obstructives, and when there is plenty of wind, and no necessity for screwing, they revolve at a furiou rate. This must, of necessity, be the case during winds and calms, and in the curved termination I apply to my system I labour under the same disadvantage. When the wind blows strongly from nearly every point of the compass, a strong current of air passes into one of my curved pipes through the drain and soil-pipe and out of the other, carrying with it any foul air that may be in the drain, but when there is a calm very little air is made to pass by natural currents. But, although I am anxious to take advantage of the passing currents of air, and they add to the value of my system by clearing the drains and pipes when the wind blows, I depend upon another power for obtaining the desired end.

In the present day, every closet is constructed so that it may be flushed by about two gallons of water; this quantity of water, if it were possible to be forced at once into the 4-inch soil-pipe, would form a solid piston of water, about a yard long, and would, in descending, push before it with considerable power the air in the pipes; and if the soil-pipe were 10 ft. long, 10 ft. of air would be displaced, and forced out of the open end of the pipe, at the same time, air would pass into the top of the soil-pipe extension, and follow the water-piston, so that during the time it was acting as a displacer of foul air, it would be filling the vacuum with fresh air; and, if I had not such an objection to mechanical valves, I could easily contrive one that would retain the yard of water in the soil-pipe, which, being released suddenly, would act with very great power, but as in practice I have found it is desirable to lay on the water for pan-flushing by a large pipe, say $1\frac{1}{2}$-inch bore, taking care that the valve which allows the water to escape from the flush tank, and also the way into the closet-pan, be of equal capacity to the pipe, a good flush is procured, and the descent of water, passing down the soil-pipe, acting in a zigzag and spiral form, produces an effect similar to the solid water piston described, and it has the advantage of being more gradual in its action, and thereby displacing more foul air than if it acted suddenly. All open-top soil-pipes having no exit pipes, lose, to a large extent, this piston power for displacing foul air, and those having an opening near the ground (as in some systems) act as I have described, but with the disadvantage that, upon each occasion of the closet being used, a portion of foul air is forced out of such an opening, and it becomes in course of time very objectionable; for we all object to a disagreeable odour under our noses, and in the vicinity of our doors and windows. The double check system has the advantage of being free from the objections I have pointed out, the soil pipes and drains being open at either end, so that any foul air in them may be displaced, are easily acted upon, and I have found that a bucket of warm water thrown down the kitchen sink has caused a current of air to circulate through the pipes; and a leaky water tap, allowing a small quantity of water to pass down the drain constantly, has during the night, and at other times, caused a moderate flow of air in one direction; and also in the arrangement of pipes, when one pipe is at the back of the house, and the other at the front, should the sun shine upon one pipe, the heat produced will cause a free circulation, so long

as one pipe is warmer than the other. Of course, the various powers described do occasionally act one against the other, there may be times when the water piston would be forcing air in one direction, and the bucket of water in the other, but in practice, this has but little effect upon the successful working of the system. Upon examination, I have found the drain and soil pipes very free from foul gases.

Some sanitarians advocate non-trapping, but I have a strong conviction of the usefulness of suitable traps for water-closets, baths, sinks, and lavatories.

The closet pans I prefer are of the wash-out type, with large flush pipes, thus avoiding D-traps and valves; and where practicable, I fix a simple form of grease and flush tank in a suitable position, so that the kitchen grease may be removed periodically, and buckets of water thrown in to flush the house drains at any time.

I have not attempted in my paper to bring before you the mode by which air and soil pipes, when in sight, should be treated architecturally, but have preferred to confine my paper to a simple description of the double check system; but I am quite alive to the fact that the treatment of soil and air pipes should have some consideration from my professional brethren. There is no reason why they may not be successfully treated so as to harmonise with, rather than disgrace, the building with which they are associated.

The models show the action of water thrown down a w.c. for displacing air; the action of air passing over the bent ends of pipes; and the action of the double check trap.

The principles I have endeavoured to establish are:—

1. That a mass of water thrown down a pipe, will force air before it, and cause air to follow it, and thereby a temporary circulation of air will take place; and if the pipes are of the form of the letter U, air will pass into one leg and out of the other.

2. That a slight current of air, entering the bent ends of a U-shaped pipe, will cause air to circulate through such pipe.

3. That a flow of air through a water trap will pass through a second trap, unless there be means provided for its exit between the traps.

HOUSE DRAINAGE. — THE BANNER SYSTEM OF HOUSE SANITATION.

By E. G. Banner.

The object of the present Conference of the Society of Arts, we are informed, is to inquire into the merits of already known systems, rather than to discuss new or untried modes of dealing with this most important subject.

That house drainage, or house sanitation, as it is now pretty generally called, is a most important matter, no one now hesitates to admit. It is as fully admitted, notwithstanding the great advance that has been made, within the last few years, in the true knowledge of it, by some who have carefully studied the subject, that the community at large, including both the wealthy and educated classes, remain in almost entire ignorance of it, and so fall an easy prey to ignorant or inexperienced practitioners.

When we are authoritatively told that an immense number of deaths occur annually in the United Kingdom from preventible causes, nothing more need be said in proof of its vast and daily increasing importance. No one, however high his or her station, should be above seeking for full information on the subject, however disagreeable even thinking of it may be; and anyone who has given free and unbiassed consideration to it, and who feels he can add to the general store of knowledge, would fail in his duty to his fellows, if he omitted to respond to the invitation which this Society has again this year sent out; for among the many very important matters which constantly claim and receive the careful attention of the Society of Arts, it may be safely said there is not one of greater importance than that which forms the subject of the present Conference—the public health.

The subject, no doubt, is a very broad one, and has, therefore, of necessity, to be considered under various heads; at present it is proposed to inquire only as to the best means of obtaining and securing an ample supply of pure water, and wholesome houses. These two branches are so dependent, the one on the other, that without we secure both we shall not obtain the benefits of either.

The remarks I have to offer will apply almost entirely to the latter branch; and, if allowed to do so, I will demonstrate the force of them with models, which I have had prepared for that purpose.

Up to within the last year or two, the invariable practice of sanitary engineers was to rely on a multiplicity of traps, with the aid of water, for keeping houses free of sewer-gas. Innumerable kinds of traps were made for the purpose—some of them very ingenious. Not one, however, was equal to the duty required of it; to overcome the defect two were often used, and sometimes more, with, however, this extraordinary result, the greater the number of the traps used the further the engineer or architect found himself from what he was striving so perseveringly to accomplish, viz., a house free from sewer or sewage-gas; and, in fact, the house generally became the worse in this respect in proportion as the number of the traps used was increased.

I am alluding to the ways in which it was, until recently, usual to deal with the house drain, and the soil-pipe proper. In order to lessen the danger, it was not unusual to put separate pipes to carry off bath and other less offensive wastes, and to deliver them outside the wall of the house, above an open trap having a grid over it, this trap itself having only the insecure water seal as a protection against the drain or sewer to which it led. Sometimes the soil-pipe proper was what was called "ventilated," and I will show you directly what kind of ventilation this really was—that, in fact, it was not ventilated at all.

First, let me show you how utterly unreliable any mere water seal is as a trap against sewer-gas entering a house from a drain or a sewer.

You are aware, of course, as water passes down or along a pipe or drain, that the sewer gas, of which both are usually full, is driven past such traps, sometimes outside the house, but most frequently into the lower rooms. To prevent this really great danger, by what is still called "re-

lieving the pressure," when water, &c., passed into and down a soil-pipe, sanitarians carried the soil-pipe, full bore, to the roof, or a little above the top closet, often as high only as an upper bedroom window, and we find a caution against the latter practice in the latest and best works on sanitary engineering, by such authorities as Latham, Denton, and Eassie, as well as, in "Practical Hygiène," by the late Dr. Parkes; and I may mention, too, as an authority on this subject also, Mr. Rogers Field; for, though I believe he had not, until 1876, written any book upon the subject, what he has given since as, in his opinion, the best mode of dealing with house drainage, is substantially what I put forward during the Congress held at Brighton by the National Association for the Promotion of Social Science, in the autumn of 1875, when he did me the honour, on my invitation, of testing, in the severest way he could, the system which I had introduced by my lever-trap of 1872, and my exhaust-cowl of 1874, and which, at the time he saw them, had been in operation—most successful operation—for a year or two, with the inlet which I had discovered was necessary for fresh air, to the foot of the soil-pipe.

The talented author of "Sanitary Arrangements for Dwellings" also told me, in 1875, that my system was new to him, as did also Mr. Ernest Turner. I think it right to mention these facts, because there has been an attempt made lately, for some purpose or other, to disparage the usefulness of cowls. It is pretty well known that I do not endorse that opinion. I consider, however, that the point, if it really is still to be disputed, ought to be fairly and properly determined in the interest of the public alone, and it, no doubt, is a matter which may properly be sidered on an occasion such as the present.

Before I proceed to show you what, only a very few years ago, was thought by the most advanced sanitarians to be a "ventilated" soil pipe, let me give you clear proof of the exhaust power of the cowl I introduced in 1874. In proof of the great power of these cowls I will take this curved one-inch tube, in which the friction surface is three times the superficial area, and you will see that, on a length of 60 feet, with a common pair of bellows, the exhaust power of the cowl is sufficient to suck out a lighted taper held at the other extreme end of the tube. Now, 60 feet is far more than the ordinary length of the soil pipe of a house, it is never less than four inches in diameter, it is generally placed not only straight but vertical, which alone it is said gives it a decided advantage over a similar tube placed horizontally, while the friction surface in a four-inch tube is relatively only one quarter what it is in a tube like this of one inch diameter.

Now I will show you what, until very lately, was considered to be a ventilated soil pipe and cesspool. You thus see, in truth and in fact, that it was really not ventilated at all; and, being always, as it was, full of sewer gas when only so "ventilated," whenever water, &c., passed down the soil-pipe, there was the certainty of the said sewer gas being driven by it through the traps beneath the lower closets, or of its being drawn by the heat of the rooms, into the house. Another very dangerous consequence of such ventilation is, that the upper part of the trap, as well as the upper side of the branch pipe leading from the trap to the soil-pipe, soon, and often very soon, was eaten away by the sewer gas, and then, of course, there was a highway always for the sewage gas generated in the traps, soil-pipe, &c., to pass freely into the rooms at all times.

By the system which I have already said was originally introduced by me a very few years since, no such dangers can exist, as a current of fresh air is constantly passing up the soil-pipe, and another similar current, separate and distinct from that made to pass up the soil-pipe, is also made to pass through the house drain, thus affording, and I contend in the very best way, a double security against any sewer or sewage gas entering a house.

What is known as the water-carriage system will be admitted as the most convenient as well as the simplest, and, therefore, as the best for the promotion of public health.

Ventilation—I must emphasise the word, and say real ventilation—of all the pipes and appliances necessary for carrying out that system is now pretty generally known to be an indispensable desideratum. Since I first introduced the simple mode and means of effecting it, we have had numerous other spurious plans proposed, but I shall, perhaps, be excused for saying that, in my humble opinion, not one of them is as perfect as the original.

Proper arrangements are needed, both for the admission of fresh air to the drain and the soil pipe at proper points in each, as well as for its being drawn not only into but through them, and made to escape above the roof of the house instead of near the windows, as used to be generally the case.

It will scarcely be allowed to me to enter into the many minor details which are necessary to ensure the thorough efficiency of the system, which I claim the credit of having introduced. Permit me, briefly, to mention some important points. It is comparatively unimportant whether the drains pass under the house, and whether the soil pipe happens to be within or outside the walls of the house, and what position in it the closets happen to be; for if even they are in the middle of the house—as very often happens in London—with proper arrangements they, nevertheless, and generally without much expense, can be made perfectly safe.

As I have already shown, no mere water seal can be relied on in any trap, to prevent gas from the sewer entering a house, if the house drain and soil pipe are not ventilated as I have shown they can be, and, as I venture still to think, they always should be.

We have hardly yet got a perfect closet, perhaps. The first trapless closet introduced, so far as I know, was Pearson's; others have been brought out since, which do not surpass it; but a well-made and well-kept pan-closet, I continue to think—and they are the kind mostly used—will be found all that is necessary for comfort and perfect safety, provided no traps of any kind are put immediately below them. The system, however, which I am advocating is quite independent of any particular kind of closet, but I unhesitatingly assert that any closet having a perpetual trap below it, or forming a part of it, is a decidedly imperfect one. I am aware that what is called a "wash-out" closet is approved by some. My objection to it is the same as to the

common hopper closet, viz., it really prevents thorough ventilation, and requires an extra supply of water to flush it properly.

A very strenuous endeavour has been made to disparage the system I am advocating, by asserting that cowls are not necessary, and that they are liable to become fixed; this, I beg to say, when they are properly made and properly stayed, is as unusual as is the breaking of the mainspring of a watch. An endeavour has also, I am told, been persistently made to have it believed that the system is an expensive one to carry out, while, in truth, the very reverse is the fact; by its adoption much lighter lead pipes may be used with perfect safety, extra pipes for the waste from baths and sinks are rendered quite unnecessary. Iron pipes may be used instead of lead, and the same pipes, of whatever material, may be used, not only for soil and bath wastes, but for rain water also; and as there is never any sewer or sewage gas in any of the pipes, the portions of them needed for ventilation only may be of zinc instead of lead, as is necessary under the old plan. As confirmatory of this, I may mention that, in two recent instances the cost of carrying out the system, as compared with the estimates for what was proposed to be done at each on the old plan, was actually very little more than one-half.

This drawing shows the lever trap and its arrangement as introduced by me in 1872, and exhibited at the last International Exhibition in 1874. In this case the fresh air is brought to the foot of the soil-pipe by means of the rain-water pipe. It would be impossible of course to show all the many different ways of bringing fresh air there. The mode of doing it is a matter of perfect indifference so long as it is allowed, by any proper arrangement, to get there.

Some gentlemen believe that fresh air, of its own accord, will go on a perpetual voyage of discovery down one pipe and up another, for the purpose, I suppose, of hunting out any sewer gas there may be in either. Another gentleman has lately made the further discovery, important, if it be true, that the said fresh air hunts perpetually up an open pipe during the day, and down it during the night. All I will say is, I do not agree with the learned advocates of either doctrine, and that to overcome the opposite belief I introduced the cowl I have shown you the power of, and of which this is a section. This cowl, as well as the lever trap, and its arrangement, was exhibited at the Sanitary Conference, at Glasgow, in 1874, and in proof of its excellence, I may say it has since been imitated by many, and by some, as I think, unscrupulously.

An eminent medical man told me the other day that if he were obliged to dispense with one of two of the most important things known in his judgment, viz., medicine and pure air, he would do without the first—throw physic to the dogs, in fact. You will probably agree with me in thinking this is strong testimony in favour of wholesome houses, and I trust that, now there is really reasonable ground for hope that the death-rate, ere very long, will be reduced from 34 per 1,000, in some towns, to 17 per 1,000 throughout the whole kingdom, and that the average duration of life, instead of being, as at present, 49, will be raised to, say, 60, Apart from the probable great lessening of the actual death-rate, what an immense diminution of disease and sickness do such hoped-for results point to nevertheless, in their honour and praise be it said, there are in no class or profession in the kingdom, more sincere, or more earnest advocates than medical men for unpolluted pure water. My friend, Dr. Richardson, stands out prominently now among the crowd in advocating this and a sufficient supply also of really pure air in wholesome houses.

I hope I shall be excused for saying that I do not think we have yet arrived at the best way of dealing with sewers, though they are truly a place of filth, and must, to a great extent, remain so. The present great inconvenience and danger which they occasion, might, I am persuaded, be very greatly diminished if not altogether avoided. We are told it is a great mistake not to ventilate them, but the means at present taken to accomplish this is so very objectionable, that in many places we see the plan most strenuously opposed. The plan pretty generally adopted, where the need of ventilation is admitted, is to make openings for the purpose through gratings in the middle of the street down to the sewer: these gratings, however, are rarely large enough and numerous enough to be of any effect for good, while they often do an immense amount of mischief. I will take such facts as will be admitted to exist within a radius of a mile or half a mile of this spot. The sewers are very large, I suppose at least 10 feet diameter. Between Adam-street and St. James's-street, a distance of about 1,350 yards, I find there are four gratings, such as I have mentioned, in that length of sewer. When the gratings are not stopped up, which in fact they generally are with dirt, there is one grating to every 1,000 feet of sewers; each grating affords about 50 inches of air space, while the cubic inches of air space each is expected to ventilate is about 200,000,000. Clearly, then, such openings cannot be of any effect for good, while at times what escapes may destroy life. Sometimes gratings are put under gateways, and very generally at crossings; in the latter case, I suppose, because such points are the junction of sewers as well as streets, and it is thought that at such points they serve to ventilate the sewers under all the streets more effectually, while really they do next to absolutely nothing beyond ventilating a few feet of only one. If an opening exist in an unventilated air pipe, we know how dangerous as well as offensive that is; these gratings, opening into sewers, are scarcely less offensive, and serve, I verily believe, no really useful purpose. In Paris openings into the sewers are at the sides of the roadway, which, I think, a better plan than that adopted in London, but with other arrangements for delivering the waste from houses into a properly ventilated drain with one delivery from the latter into the sewer, I incline to think that gratings opening into the sewers might be almost entirely dispensed with, and the constant ripping up of the street avoided.

I am aware that some objection at present is taken to a single drain being made to serve for even two houses, but by the plan I am about to suggest this objection would not arise. I think there is, as yet, no possibility of really ventilating a large sewer. I am certain it is quite easy to perfectly ventilate a large drain, a drain large

enough to serve for 50 or 100 houses. The suggestion I have to offer is, that such an intercepting drain, of, say, about 12 in. diameter, might be made to run parallel with the sewer, with but one delivery from it into the sewer, which could easily be trapped; each house could have its own drain as now, but instead of being led directly into the unventilated sewer, should deliver into an intercepting ventilated drain, while the soil-pipe, the foulest pipe within each house, could easily be separately and most effectually ventilated also. Thus, I feel quite certain, all danger from sewer drains and soil-pipes would be done away with.

The intercepting drain should be placed under the control of some duly constituted authority in each parish or district, which would be responsible for its being kept in proper order, both as regards flushing and ventilating; and it may even be found practicable to collect the solid part of the most impure matter at each delivery into the sewer, deodorise it there, and remove it periodically to where it would be useful as manure, instead of, as now, passing it into streams, and rendering them unfit for use.

CINDER-SIFTING ASH-CLOSETS.

By I. Conyers Morrell.

This system, which I invented some years ago, is now so well known throughout the country, that it is scarcely necessary to describe it. To those, however, who may not be acquainted with it, the following brief description will convey some idea of its value.

It is the only known system which is capable of utilising for sanitary and economical purposes the waste material which is found at every house. This material, under the old system, is consigned to what is known as a midden, or ash-pit, and is mainly composed of ashes, three-fourths of which are, on examination, found to be cinders, and the remainder fine ash-dust. This latter has been shown by Mr. Watts, in his "Dictionary of Chemistry," and by Dr. Stoekhardt, in his "Chemistry of Agriculture," to be of great value, on the one hand, as a deodorant and absorbant; and, on the other, for agricultural purposes as a manure.

If any person will take an ordinary hand-riddle of fine mesh, separate the cinders from the dust, and scatter the latter with a hand-scoop over the night soil of a closet, he will find that it keeps down all smell, and so prevents the offensive and injurious effects of human excrement. He need scarcely be told to put the sifted cinders on to the fire, and utilise them as fuel. But the operation of sifting cinders in this manner is so laborious, irksome, and uncleanly, that it is not likely to be carried out by any but those who are keenly sensitive on the observance of sanitary laws, and as these are found as yet, even after years of lecturing, to be a very small minority, we cannot rely upon the labour being voluntarily performed by many. Hence the invention of this cinder-sifting ash-closet, which is designed so that by a self-acting arrangement the cinders are sifted, and a dose of the fine ash-dust is scattered over the soil on each use of the closet. The ashes, as they come from the house fire-grate, are merely thrown through a hole in the wall, and find their way on to a sloping screener attached to the rear of the closet. By the pressure upon the seat, on use, this screener receives a motion by which the cinders roll down its incline, and fall into a space where they are ready to collect for re-burning; the ash-dust falls through the sieve into a hopper, and thence to a scoop which, on the person leaving the seat, delivers a dose of this dust on to the soil immediately below the seat. The most recent improvements have been to secure all the above being done by one moving part in the whole arrangement, so that the simplicity of the appliance is perfect, and is such that nothing less than absolute wilful damage can put it out of order. The receptacle for the soil may be either a movable pan or a fixed vault. If the pan is used, which at the present time is most general, its removal takes place at weekly intervals. If the vault is used, its contents may be collected, without the man entering the vault, and carried away at monthly intervals. Where a regular system of collection can be relied upon, perhaps the movable pail is the best. This is held to be so by medical authorities at the present day. For some reasons I should not, however, be surprised to see the movable pail give place to the fixed vault, as, for one reason, I cannot help thinking that the vault would prove the most economical in collection. Over three thousand of these closets are in use in the Pendleton district of Salford, where the movable pail is the receptacle. The practice there is to carry the full pail away, and replace it by a clean one. The full pails are conveyed in a specially constructed cart to the corporation manure depôt, where the contents undergo a treatment which consolidates them into a valuable manure that meets with a ready sale. At this depôt, arrangements also are provided for utilising the garbage and other refuse which are brought to it from the dwellings in a separate receptacle. For my own part, I must confess that I should prefer to see the manure offered to the farmer in its crude state, just as it leaves the soil receptacle. This may, however, be difficult where the system is not universal in the district, as in such cases provision has to be made for dealing with the refuse collected from the old system of closets as well.

It will be understood that whether a movable pail is used, or a fixed vault, under this system, the contents will be an equal mixture of soil and dry-ash, and that, accordingly, the refuse is more or less a dry inoffensive mass of valuable manure, in appearance resembling dark mould, and of a consistency which renders its removal an easy matter even if the vault is used. The absence of a deodorant and absorbant renders the receptacle during use most offensive, and so I can understand why the tub system is condemned by many. The contents are always in a slushy state, and besides being injurious during use, are difficult to remove, hence the complaints we hear of during the removal of the tubs to the manure depôt, complaints which cannot possibly arise where this ash-closet system is properly carried out. I believe that medical authorities advocate the tub system, because the contents are by it carried bodily away, but it is difficult to understand how

some of these leaders in the van of sanitary improvement can reconcile themselves to the filthiness and offensiveness of a tub of human refuse remaining exposed, as it does, during a use of at least seven days. I can only explain this by supposing that the advocates of the tub, pure and simple, are not acquainted with the fact of there being a better system.

The advantages of the cinder-sifting ash-closet may be enumerated as follows:—

It costs no more, in its application to new premises, than the old midden system. It is perfect as a sanitary improvement. It economises fuel. It makes a valuable manure of that which is comparatively valueless under any other system. It reduces the cost of removing refuse, inasmuch as it leaves the greatest portion of the bulk on the premises in the form of cinders. It prevents the injury of land, by covering it with a layer of cinders whenever night soil from middens is used for manure. It can supplement the ashes with any other dry material, such as dried earth, if at times it is desired to do so. It requires no extra attention. It cannot get out of order. It is applicable to any premises, and is equally suited to the mansion and the cottage, to schools and public institutions, to all of which it is extensively applied. It prevents the pollution of well waters. The closets are constructed in portable and skeleton forms, and are supplied only by the Sanitary Appliance Company, Limited, of Salford.

The following report of a deputation from a neighbouring town, who visited Pendleton to see the system in operation, should suffice to satisfy sanitary reformers that they may find in it the much-desired remedy for the evils common to the old midden and cesspool, without incurring the dangers that follow from the adoption of what is known as the tub system, or from the adoption of the water-closet system:—

"They were first shown the 'Morrell' closets. These are really *pail* closets, with the addition of a cinder-sifter, so adapted that, by mechanical contrivance, a certain amount of fine ash is thrown into the pail every time the closet seat is relieved from pressure. The fine ash absorbs the urine and gases in its pores, and becomes more or less intimately mixed with the solid excreta. By this adaptation, the contents of the pail are not in that slushy condition observed in all cases where the pail receives only the human solid and liquid discharges, and the first stage in the preparation of a good, useful manure is thus done automatically.

"These closets were particularly free from smell, and were very neat and clean. Salford has tried the simple pail, but has now discarded its use in favour of Morrell's improvement of it.

"Every new house has its own separate closet, and old houses are compelled to have, at least, one closet to two dwellings. The pails are replaced at least once a-week, and conveyed in a covered van in daytime to the depôt at Salford-bridge. Here, one by one, they are emptied into an iron mixing trough, more fine ash thrown in along with a small quantity of sulphate of lime, and in a few minutes is discharged from the trough a dry, portable manure, in the course of a few hours quite free from smell, and sold at 12s. 6d. per ton. The coarse ash and clinker are ground in a mortar mill with sand and lime, and form an excellent mortar, readily saleable at 5s. 6d. per ton. The works are of very unpretentious character, the machinery simple, yet efficient, and the offensiveness as small as possible."

MISCELLANEOUS.

THE DEVELOPMENT OF THE USE OF STEEL DURING THE LAST FORTY YEARS.*

By J. Robinson, Pres. Inst. Mech. Eng.

Much has been written by poets and others of a succession of the ages of the human race, in comparing their degradation with the various kinds of metal, considered metaphorically—thus we have the golden age, the silver age, the age of brass, and the age of iron.

Our own time may very appropriately and literally be described as a branch of the latter age, and be named the age of steel.

In the metropolis of the steel manufacture, it would seem fitting that the mechanical section of this great scientific association should direct its attention to this wonderful metal, the uses of which are daily becoming more numerous and important.

But it may be said, on the other hand, that as the use of this material is perpetually growing more common, so are discussions as to its manufacture, composition, and characteristics, becoming almost wearisome from their frequency.

Notwitstanding an appearance of truth in this objection to our occupying more time in referring to the subject, I would venture to entertain the hope that a treatment of the question, in its mechanical and economic aspects, may prove not uninteresting to this meeting.

At the time when railway extension was becoming general, about forty years ago, the use of steel in this country was confined mainly to tools for mechanical purposes, including files and other articles, springs for vehicles, weapons of various sorts, and implements for agricultural and domestic uses; and it is proposed to measure the scientific and mechanical energy brought to bear upon the manufacture and improvement of this metal by the increase in the number of purposes to which it is applied, and the diminished price at which it can be obtained, as compared with the price at the time of its introduction for constructive works. There are, however, several important exceptions to this method of appreciation to which reference will hereafter be made.

We will take, then, the simplest form in the preceding list, viz., tool steel, the price of which for ordinary purposes varied from 50s. to 56s. per cwt. at the period I have named; and we shall find that the development of the manufacture of steel in general has but little affected this particular material, which is still produced in much the same fashion, *i.e.*, by the use of carefully selected Swedish iron, carburised by exposure in ovens to the heat of burning charcoal, and then recast from crucibles, and hammered down to the required size. The result of a somewhat stationary condition of manufacture has been the maintenance of prices, at the same, or about the same, level up to the present time.

A superior quality of tool steel has been produced by the adoption of a process invented by Mr. R. Mushet, in which titanium is introduced in the manufacture, and which dates back to the year 1838-39. This steel is of great endurance when applied to the working of steel and iron of considerable hardness, and its higher price of 140s. per cwt. is quite justified by the excellent results obtained from its use, and other steels of similar fine quality are produced by several manufacturers, who make specialities of them.

Some 27 or 28 years ago, Krupp, of Essen, gave an enormous impulse to the application of steel, by his method of producing much larger masses of crucible

* Opening Address to the Mechanical Section of the British Association, at the meeting at Sheffield.

steel than had previously been possible. He at that time accomplished the casting of an ingot of "crucible" steel of 50 cwt., a weight then considered incredible, and this was followed up by the production of weldless cast steel tyres in 1852, which led to the very rapid development in the use of his steel for railway tyres, cranked axles for locomotive and other engines, straight axles and shafts, and parts of machines in general.

It is most interesting to consider the prices of such of these objects as have up to this time maintained similar forms, with the object of ascertaining, by the selling price, the progress in the scientific and mechanical appliances used for the production of the materials just referred to.

At the time of their coming into use, about twenty-five years ago, the price of cast steel tyres was 120s. per cwt.; it is now from 18s. to 25s. per cwt. The price of forged steel cranked axles was, when first introduced, £15 per cwt.; it is now from 65s. to 70s. per cwt.

The price of straight axles and shafts was from 40s. to 50s. per cwt.; it is now from 19s. 6d. to 23s. per cwt.

Now, to what do we owe this enormous reduction of price and consequent more frequent and more economic application? The answer must be that, following the initiation of Krupp, our English engineers and men of science set themselves to work to discover and apply new processes for the production and manufacture of this most wonderful metal; and I venture to say that in the whole history of metallurgy, from the time of Tubal Cain downwards, there has been no such progress in invention and manufacture as has been realised by the aid of such men as Mushet, Krupp, Bessemer, Siemens, Whitworth, Martin, Vickers, Bell, Bauschinger, Styffe, and many others within the period comprised in this retrospect; and our national predilections will perhaps lead us to the opinion that our own country may fairly appropriate a large share of merit for the results achieved.

Another of the uses of steel to which attention may be given is that of the production of cannon of large size.

Efforts have been made by some of our enterprising workers in metal to produce large guns of solid wrought iron; but the processes of heating and hammering were attended with so much difficulty that the attempt was given up. Here again, Krupp stepped in, and succeeded, 32 years ago, in manufacturing cannon of cast steel, which, unhappily, have become ordinary commodities with those nationalities who could afford such expensive weapons. Since that time Krupp has produced about 2,000 guns, the heaviest being, when finished, 72 tons (16 inch).

Sir William Armstrong and Sir Joseph Whitworth soon came into the field with guns of their own invention; the former, by adopting the system of iron coils applied externally to a central cylinder; and the latter, by shrinking cylindrical hoops on to a central cylinder made of cast steel.

In the adaptation of the steel manufacture of the cast or crucible steel period to the production of every object demanded by the march of engineering and mechanical science, I need not mention the names of individuals and firms in this town who have shown themselves equal to the task; but I will venture to say that their success has been such as to raise the town of Sheffield to the very pinnacle of fame, as producing steel of any, even the highest, quality demanded in the markets of the world.

I must now turn to a name honoured everywhere for the benefits and renown he has brought to his country by his inventions and appliances, developed during the last 24 or 25 years, in the manufacture of a steel which can be cheaply produced and readily adapted to the requirements of the purchaser. I am sure the audience will, in their minds, anticipate the record of the name of Bessemer—a name which will be handed down to posterity in connection with the manufacture of steel as long as that manufacture exists.

Another name which will most deservedly figure in the history of the development of the steel manufacture is one, like that of Bessemer, which has been known not only in that development, but in connection with many other discoveries in physical science—I mean that of Siemens, who, like his compeer, has not only invented processes, but has personally carried them out into practical application. An expression let fall by the latter, as President of the Iron and Steel Institute, at its meeting last year in Paris, exhibits very strikingly the absence of any other feeling on the part of these two great men save that of the most friendly rivalry.

Speaking of a comparison between the results of steel manufactured by the Bessemer blowing process and the Siemens-Martin open-hearth process, Dr. Siemens said, "He did not see how the result could be the same. It might be better in the Bessemer process than in the open hearth for aught he knew, but it could not be the same;" and it seems to augur well for the advancement of science in our day, that so little of a contrary spirit is exhibited in the discussions which ensue from time to time, upon any improved process, either chemical or mechanical, having for its object the production of a better material at a lower first cost. The name of Robert Mushet may very properly be introduced here as one of our early inventors of the improved processes for the manufacture of steel, and it is gratifying to find that other countries besides England have learnt to appreciate the results obtained by him during so many years of scientific and experimental research.

It is needless that I should do more, in an assembly like that before me, than refer, in the simplest terms, to the differences in the processes of manufacture connected with these names.

In that of Bessemer, pig-iron of a selected quality is charged into what is technically called a "converter," a large cast-iron vessel into which air can be blown at considerable velocity by suitable blowing machinery. This goes on until the iron is thoroughly oxidised, and the impurities contained in the metal are driven off. When this happens, the blowing ceases, and a certain proportion of spiegeleisen or of ferro-manganese is added to the charge, so as to give the required amount of carbon. Blowing recommences, this time only to effect complete mixture of the materials, and then the casting of the ingots, takes place of a quality corresponding to the metals selected for the mixtures. A mild steel—or, as it has been called, a pure iron—is the resultant, and it is capable of being worked, welded, or hammered very much as in the case of the purest wrought irons; but it possesses generally a much higher tensile resistance and a greater ductility.

In the Siemens-Martin, or open hearth-process, a similar charge of pig-iron of the desired quality—probably hæmatite pig—is put into the bed of a reverberatory furnace of the generative system, and the necessary oxidation is produced by adding to the molten mass iron ores, or oxides of iron in proportions ascertained by experience, after which re-carbonisation is obtained by the addition of ferro-manganse or spiegeleisen, as in the Bessemer process.

These processes have been the great factors in that reduction in the cost price, and, therefore, in the extension of the use of such objects as steel tyres, axles, shafts, rails, &c., to which I have already referred, and which is so striking an instance of the results which our men of science can accomplish, by their physical and experimental research into the means of supplying the wants of our work-a-day world.

I will now draw attention to another product of the steel manufacture which is of immense importance, and which could not have been obtained for ordinary purposes, but for the facilities of manufacture arising out of the inventions I have just alluded to—I mean

that of steel castings, *i.e.*, castings obtained from the crucible, precisely in the form in which they are to be used in the construction of machinery, just as is the case in ordinary cast iron run from the cupola furnace. This production of castings for engineering purposes is gaining an enormous and rapid development; and when it is considered that in this metal we obtain castings of a strength at least three to four times that of the strongest iron castings, the importance of this experimental discovery can scarcely be overrated.

Nor must I pass over the application of these processes to the production of boiler plates, bridge girder plates, and ship plates, in which, as a result of the greater tensile resistance of such plates (reaching for ordinary uses a figure of about 28 to 34 tons to the square inch), the engineer is not only enabled to lighten his structure, but to expect from it greater durability—an expectation not diminished by its greater capability of resisting corrosion, especially where care is taken to exclude manganese from the mixture of the metals employed.

For specific purposes, and where price is not so much an element of consideration as great tensile or percussive resistance, a more costly mode of manufacture has been adopted by Sir Joseph Whitworth, whose attention was probably drawn to the necessity for obtaining such a metal, during the construction of cannon and torpedoes, but which has now been extended to objects of a very varied character. The method of manufacture, which has been in use upwards of ten years, is by casting ingots under very heavy hydraulic pressures, from very carefully selected materials, the result being the production of a metal of enormous tensile resistance, reaching, in some instances, the high figure of 100 tons per square inch, while at the same time the bubbles and air vesicles, which sometimes appear in metal produced in the ordinary methods, are entirely or almost entirely got rid of, and the consequent striations and imperfections of internal structure and external surface disappear.

It is hoped that ere long we shall be able to procure in this way cylindrical boiler plates rolled solid from the ingot, much after the fashion in which weldless steel tyres are now obtained, and that the weakening of these plates by the existing necessity for forming horizontal riveted joints may thus be avoided.

It is desirable before closing this, I fear, already somewhat long address, to call attention to the most recent development of the steel manufacture as exhibited in the processes of Messrs. Snelus, Gilchrist, and Thomas, by which iron containing a considerable portion of, say, 1·44 per cent. of phosphorus, may, in the course of its manufacture into either Bessemer or Siemens-Martin steel, have this deleterious matter entirely removed, or reduced to an inconsiderable proportion.

The method of carrying out this operation was exceedingly well described at the recent meeting of the Iron and Steel Institute in London, and it was shown that, where such irons were melted in vessels lined with a slag having twenty per cent. of silica and thirty per cent. of lime and magnesia, the phosphorus was gradually and effectually absorbed by this lining, and a steel of good quality, comparatively free from phosphorus and silica, was produced.

The result to the community will naturally be that, as henceforth a much more extended area of our ironfields both at home and abroad will become available for the production of steel, the use of that metal will be still further extended, and its price reduced, mainly by means of the methodical researches of our scientific metallurgists, and entirely independently of those accidental combinations which have, in less scientific days, led to the adoption of new and improved methods in the production of metals required by the progress of mechanical and economic science.

USEFUL AND ORNAMENTAL WOODS, ETC., OF QUEENSLAND.

The following notice of the timber of Queensland will form a complement to the article on the "Cultivation of Economic Plants in South Australia," drawn from Dr. Schomburgk's catalogue of the plants under cultivation in the Botanic Garden at Adelaide, which appeared in the *Journal* of 22nd August. Queensland, the youngest of the Australian colonies, dates only from 1859. This infant colony has a sea-board 1,400 miles long; its southern boundary line, which divides it from South Australia, is 900 miles long, and it has 750 miles of sea-board in the Gulf of Carpentaria. Finally, the colony contains 669,520 square miles of surface, that is to say, more than five times that of Great Britain. This will give some idea of the possibilities of this colony. A few extracts from the official statistics will shadow forth the probabilities. The population grew from 28,056 in 1800 to 187,000 in 1876; the imports from £1,747,735 in 1807, to £3,332,900 in 1875; and the exports in the same interval from £1,989,000 to £3,857,376. The capabilities of Queensland for agricultural and pastoral purposes are immense, but her other products are numerous and highly important. The catalogue of the Colonial Commission for the Paris Exhibition gives an account of the natural products of the country, which were illustrated by specimens collected and arranged by the care of the Government. Amongst these collections were those made by Mr. Walter Hill, of the Botanic Garden, Brisbane, who has appended much information to the catalogue. As regards the timber trees of Queensland, the variety is very great, and as the diversities of the soil, climate, and altitude are great, deep ravines, sheltered valleys, and high mountain sides being found even in the same latitude, these varieties assume different characteristics in various parts.

Mr. Hill gives a catalogue of nearly two hundred different trees, and says that they do not form one-fourth of the species of economic trees which have already been described botanically, while there are almost as many more that have not yet been classified. Each district of the immense colony is characterised by vegetation peculiar to itself, and it will be long before all are botanically classified and catalogued for economical purposes. Nothing but the stimulus of a demand for exportation will much hasten these processes.

The value of some of the Australian eucalypti for building and railway purposes has been well established, but Mr. Hill says that there is little doubt that many of the trees, even though broadly differing in a botanical sense, produce timber which, in appearance, is identical. There are also a variety of other trees yielding timber remarkable for strength, durability, fineness of grain, or ornamental appearance, which render it eminently adapted for cabinet work.

Mr. Hill has treated his specimens not only fully, but at once botanically and economically, giving in all possible cases the present value of the timber. The following extracts give the most characteristic of the items:—

Amongst the coniferæ, *Araucaria Bidwilli*, called by the aborigines "Bunya Bunya," is remarkable. This tree grows to the height of one to two hundred feet, and attains a diameter of 30 to 48 inches. This noble tree inhabits the scrubs in the district between the Brisbane and the Burnett rivers, and in the 27th parallel it extends over a tract of country about thirty miles in length and twelve in breadth. The timber is strong and good, and full of beautiful veins, works with facility, and takes a high polish. The cones of this tree measure 9 to 12 inches in length, and as much as 10 inches in diameter; they grow points downwards.

Araucaria Cunninghamii, or Morton Bay pine, grows to about the same height as the preceding, but reaches a diameter of 36 to 66 inches. It is described as one of

the most useful trees in the colony, and is already in large demand there and in the southern colonies. It covers immense tracts of country. Its wood is strong and durable, either when dry or actually under water, but it will not bear alternations of dryness and damp. When grown on the mountains of the interior the wood is fine grained, and takes a polish which is described as superior to that of satin-wood or bird's-eye maple. The present price of the wood is from 55 to 70 shillings per 1,000 superficial feet.

Dammara robusta, the Kaurie or Dundathu pine, does not reach the same height as the two preceding, but it attains even to 72 inches diameter. The wood is like it in quality, and is worth 70 shillings per 1,000 feet.

Callitris columellaris, called the Cypress pine, is another remarkable tree, of less size than the others, but attaining a diameter of 40 inches. It is plentiful, and in great demaud for piles and boat sheathing, as it resists the attacks of cobra and white ants, while the roots give good veueers. The wood is worth 120s. per 1,000 feet.

Podocarpus elata, or she-pine, attaining 80 feet in height, and 36 inches in diameter; timber free from knots, soft, though closed and easily worked, used for joinery and for spars. Very common; worth 65s. to 70s. per 1,000 feet.

Frenela Parlatore and *F. Endlichera* are similar trees, reaching 36 to 40 inches in diameter.

The *Casuarina equisetifolia*, or swamp oak, and *C. torulosa*, or Forer oak, yield light, tough, beautifully marked wood, reaching from 12 to 18 inches in diameter.

A superb specimen of *Meliaceæ* is *Cedrela Toona*, the red cedar, 100 to 150 feet in height, and 24 to 76 inches in diameter, found in abundance on the coast and inland. The wood is light and durable; it is largely employed in joinery and furniture work, and from the junctions of the branches with the stem beautiful veneers are obtained; value 150s. to 170s. per 1,000 superficial feet. There are several varieties of *Flindersia*, known as flindosa, light yellow wood, bogum-bogum, and spotted tree. Smaller trees, yielding hard durable wood, the sour plum, *Owenia venosa*, wood of great strength, up to 18 inches diameter. The sweet plum, also small, with dark red hard wood, finely marked, and taking a very high polish; the pencil cedar grows to the height of 70 to 90 feet, and yields timber 20 to 40 inches in diameter, much used, worth 100 to 120s. per 1,000 feet; the white cedar reaches nearly the same size.

Belonging to *Rutaceæ* is the native orange, *Citrus australis*, found in abundance; wood hard, close, and light yellow in colour. The native lime yields similar wood. The *Pentaceras australis*, also known as white cedar, yields close-grained, tough, firm wood, 12 to 14 inches in diameter. The so-called satin-wood, that of the *Zanthoxylum brachyacanthum*, yields fine yellow wood up to 9 inches in diameter.

Fine species of *Celastrineæ*, such as *Siphonodon*, *Denhamia*, &c., yield fine hard wood, susceptible of high polish, ranging from 3 to 24 inches in diameter.

The mountain ash grows plentifully in the colony, reaching 45 to 80 feet in height, and 18 to 24 inches in diameter. The timber is hard, close-grained, and durable, takes a high polish, and is used for gunstocks and other like purposes.

The native pomegranates and other *Capparideæ* yield fine, hard, close-grained timber, from 6 to 14 inches in diameter.

There are many species of *Sapindaceæ*, some of which yield fine, close, hard wood, the native tamarind being one of these; but the most important of this family is the tulip wood (*Harpullia pendula*) tree, which grows to the height of 50 or 60 feet, and yields plants 14 to 24 inches wide, of close-grained and beautifully marked wood, highly esteemed for cabinet work. Another valuable tree is *Rhus rhodanthema*, or dark yellow wood tree; it grows of a moderate size, yielding planks up to 24 inches in width; the wood is soft, fine-grained, and beautifully marked; this tree grows by the sides of all the rivers; its wood is highly esteemed for cabinet work, and is worth from 100 to 120s. per thousand feet.

There are five trees of the order *Rubiaceæ*, all yielding good timber. Of these, Leichardt's tree, *Sarcocephalus cordatus*, is the most important, growing to 24 and 30 inches in diameter. The others are small trees. The *Myrtaceæ* are, however, the grand trees of Australia. Amongst these are the bottle brush tree, *Calistemon lanceolatus*, a smallish tree; the broad-leaved tea tree, *C. Salignus*, of larger growth, yielding hard, close-grained wood, some of which is said to be very durable under ground; the white tea tree, *Melaleuca leucadendron;* the prickly-leaved tea tree, *M. styphelioides;* the tea tree, *M. nodosa*, and two others of the same tribe, which yield fine hard wood, admirable for damp situations. The wood of the prickly-leaved tea tree has never been known to decay. These trees vary in diameter from 10 to 40 inches. The *Augophora subvelutina*, or "apple tree," yields planks from 20 to 30 inches in diameter, the wood being very strong and durable, and much used by wheelwrights and for ships' timbers. Of the wood of the *Eucalyptus*, twenty-four varieties were exhibited, and as this wood is now attracting much attention, and is of great importance, it will be well to give the characteristics, botanical and local names, and sizes of them.

Eucalyptus pilularis, or black-butt.—Height, 60 to 70 feet; diameter, 20 to 40 inches; excellent for carpentry.

E. hœmastoma, or spotted gum.—Height, 60 to 120 feet; diameter, 24 to 48 inches; first-class for ship-building, wheelwright's work, &c.

E. microcorys.—Height, 60 to 80 feet; diameter, 18 to 36 inches; for wheelwright's work.

E. hemiphloia, or yellow box.—Height, 50 to 75 feet; diameter, 20 to 40 inches; famous, hard, tough, and durable timber.

E. siderophloia, or iron-bark.—Height, 70 to 100 feet; diameter, 20 to 40 inches; highest reputation for strength and durability; used for large beams.

E. melanophloia, or silver-leaved iron-bark.—Hoight, 30 to 70 feet; diameter, 18 to 24 inches.

E. maculata, or spotted-gum.—Height, 60 to 80 feet; diameter, 20 to 36 inches; wood very valuable, strong, and elastic; in bridge building it has been found to have the highest constant strength of all the Queensland timber.

E. saligna, or grey-gum.—Height, 60 to 90 feet; diameter, 24 to 40 inches; strong and durable timber.

E. resinifera, or red-mahogany.—Height, 60 to 70 feet; diameter, 20 to 30 inches; much used for piles, &c.; very durable.

E. corymbosa, or blood-wood.—Height, 50 to 60 feet; diameter, 24 to 30 iuches; good durable wood for posts, &c.

E. botryoides, or blue-gum.—Height, 70 to 100 feet; diameter, 30 to 50 inches; hard, tough, and durable; excellent for ship-building and felloes of wheels.

E. tereticornis, or red-gum.—Height, 60 to 90 feet; diameter, 18 to 36 inches; used for ship-building, shafts of drays, ploughs, beams, &c.

E. Stuartiana, or turpentine-tree.—Heght, 60 to 90 feet; diameter, 24 to 40 inches; hard, and very durable for sleepers, &c.

E. fibrosa, or stringy-bark.—Height, 40 to 75 feet; diameter, 18 to 36 inches; good for flooring.

E. tesselaris, or Moreton-Bay ash.—Height, 30 to 60 feet; diameter, 14 to 24 inches; wood brownish, not hard, but tough; used in building

E. melanophloia, or silver-leaved iron-bark.—Height, 30 to 60 feet; diameter, 18 to 24 inches; used for fencing.

E. platyphylla.—Height, 60 to 80 feet; diameter, 20 to 30 inches; used in carpentry.

E. crebra, or white, narrow-leaved iron-bark.—Height, 70 to 90 feet; diameter, 20 to 36 inches; excellent hard timber for building.

E. leptophleba.—Height, 50 to 80 feet; diameter, 18 to 36 inches; hard and durable.

E. setosa.—Height, 40 to 50 feet; diameter, 18 to 24 inches; used for fencing.

E. terminalis.—Height, 40 to 50 feet; diameter, 15 to 24 inches; good for posts, &c.

E. citriodora, or scented gum.—Height, 50 to 80 feet; diameter, 18 to 34 inches; hard and durable, for carpentry.

E. melissiodora.—Height, 40 to 60 feet; diameter, 15 to 24 inches; tough and durable.

E. pellita.—Height, 50 to 70 feet; diameter 18 to 30 inches; used for flooring, &c.

The market value of eucalyptus wood is from 80 to 90 shillings per 1,000 feet.

The box, *Tristania conferta*, grows to 10 feet in height, and from 35 to 50 inches in diameter, very generally in open ground; the wood is invaluable for ship-building; ribs of vessels are known to have lasted, unimpaired, for thirty and more years. There are two other *tristanias*, the wood of one being very tough, and used for cogs of wheels. Two *Backhousiæ* yield fine, hard, prettily-marked wood. The scrub-ironwood, *Myrtus Hillii*, a small tree, the wood of which is exceedingly hard. Three species of *Rhodomania* yield tough close-grained wood. Of *Proteaceæ*, the most remarkable are the silky oak, *Grevillea robusta*, a large tree, the wood of which is used for cabinet-making and the staves of tallow casks; the tulip tree, *Stenocarpus sinuatus*, the wood of which is beautifully marked and hard; and beef-wood, *Banksia integrifolia.* But there are several others—the mangrove, *Bruguiera Rheedii*, a small tree, with handsome timber and astringent bark, used in tanning; the broad-leaved cherry, and the cherry tree, *Exocarpus latifolia*, and *cupressiformis*, yield hard, handsome, fragrant wood for cabinet-work.

The bastard sandal-wood, *Eremophila Mitchelli*, is a small tree frequent in the Darling-downs district, gives very hard, handsome, and fragrant wood for veneers. The Australian beech, *Gmelina Leichhardtii*, attains a height of 80 to 120 feet, and yields planks from 24 to 42 inches wide; its wood is valuable for decks of vessels, &c., as it is said neither to expand nor contract, and is exceedingly durable; it is worth 120s. to 130s. in the market. Lignum-vitæ grows 50 to 70 feet high, and 20 to 24 inches in diameter, and is common in the moist scrubs of the coast.

The *Leguminosæ* are very common in Queensland; there are thirteen named acacias, small and large, yielding generally very tough elastic wood, in great use for various purposes. *Acacia harpophylla* attains a height of 70 feet, and a diameter of 12 to 20 inches, the timber of it being hard, heavy, and elastic, dark in colour, and with a strong odour of violets. The weeping myall, *Acacia pendula*, is a small tree, the wood of which is very close grained and violet scented, used by cabinet makers and turners, and for tobacco pipes. Another *Acacia stenophylla*, like some other trees, generally known as iron-wood in the colony, has very hard, dark, handsome wood, taking a brilliant polish.

The *Acacia striata* is curious, the trunk is beautifully streaked with green and white, and the heart is of a light yellow colour, and rather hard. The Moreton Bay chestnut is found plentifully, it grows to 80 and 100 feet in height, and 24 to 48 inches in diameter; the wood is dark and handsome, resembling walnut, excellent for cabinet work.

The musk-tree, *Marlea vitiensis*, is a small tree with with bright yellow wood, with wavy pattern, and black in the centre.

Very tough and firm timber is obtained from the *Cargillia australis*, applicable to many purposes.

There are several of the *Euphorbiaceæ*, including three of the *malotus*; the crab-tree, *Petalostigma quadriloculare*, which grows abundantly in poor sandy soil, is a good sized tree, yielding hard and fine grained wood, fit for cabinet-making.

The *Daphnandra micrantha*, a middle-sized tree, the wood of which is quite yellow, works easily, and takes a high polish.

Another pale yellow wood is that of *Chrysophyllum pruniferum.* The cockspur thorn, *Morus calcar-galli*, has dark yellow wood, used in dyeing.

The collection of fibres in the Queensland collection was remarkable; 52 kinds were shown by Mr. S. H. Eaves, of Brisbane, and nearly as many by Mr. Alexander MacPherson, of the same place, those of the *Agave*, *Dracænæ*, *Ficus*, *Hibiscus*, *Eucalyptus*, *Sterculiæ*, and *Musæ*, being the most prominent. Queensland is rich in fibre-yielding plants, but none but Queensland-hemp, *Sida retusa*, have yet been brought into prominent notice. Mr. Hill says that almost the whole of the commercial fibres can be grown there with success, and that the attention of many in the colony is drawn to their production. The directors of the Brisbane Botanical Gardens exhibited samples of two kinds of jute, three kinds of hemp, flax, *Phormium tenax*, and other fibres. They also exhibited samples of senna, dried rosella from the *Hibiscus sabdariffa*, farina made from bananas, known in Guiana as "Conquin tay," cinnamon, cayenne, and other peppers; madder, logwood, turmeric, and indigo; gum resins from the Cyprus pine, bloodwood, araucaria, grass tree, and bottle tree, which promises to be highly valuable in the arts, medicine, &c., and catechu from the *Eucalyptus fibrosa*; also blue gum, and fever bark from the *Alstonia constricta*, for medical purposes; and the bark of the iron-bark, which may be obtained in any quantity; mangrove, and green and black wattle bark for tanners.

MUSICAL EDUCATION.

The following report has been issued by the committee appointed for the formation of a new Musical Corporation, to include the Royal Academy and the National Training School for Music:—"It will be in the recollection of those interested in the advancement of musical science, that in the course of the year 1878 it was announced that the Prince of Wales had placed himself at the head of an organisation having for its object the establishment of a representative musical institution, embracing in one body the most eminent practical musicians and the most influential patrons of music. It was proposed to seek co-operation and support from all musical societies of eminence, and to begin by inviting a union between the Royal Academy of Music and the National Training School for Music. An executive committee, with Prince Christian at its head, was formed to carry the scheme into effect, and at once proceeded to open negotiations with the Royal Academy and the National Training School. Both institutions accepted the principle of union, and appointed committees to consider the details. The whole of the year has been occupied in discussing the terms of union, which consist in effect in the acceptance of a charter uniting the two bodies; such an acceptance to be binding only in the event of there being secured, through the agency of the executive committee, an annual income of at least £3,000, with other advantages, for the purpose of carrying into effect the objects of the new institution. The Duke of Edinburgh has recently communicated to Prince Christian the unanimous acceptance by the Training School of the terms of union. The charter has been elaborately discussed between the Royal Academy and Prince Christian's committee, and there remain only to be considered a few objections of little moment; but, owing to the illness of Lord Dudley, the president of the Royal Academy, the final question has not yet been submitted to the

directors of that body as to whether they are prepared to become members of the new institution on the terms above mentioned. A reply cannot now be expected before the close of the year. It may, however, be anticipated that the directors of such a body as the Royal Academy of Music will not be unmindful of the duty they owe to science and to the public; but will, disregarding any individual prejudice, accept the opportunity now offered to them of belonging to an institution which, by its apt association of professional eminence with social influence, cannot fail to exercise a just power in elevating music to its proper place amidst the institutions of the country."

LIGHTNING PROTECTORS FOR TELEGRAPH APPARATUS.*

By W. H. Preece.

For many years it was not the practice in England to protect telegraphic apparatus from the injurious effects of atmospheric electricity, because the damage done was so insignificant, and because the remedy was found to be worse than the disease. But as telegraph systems increased, as the country became enveloped in one vast network of wires, it was found that the damage done was considerable, until, in fact, about 10 per cent. of the apparatus in use were in one year damaged.

Lightning protectors then became essential. Many forms were tried, based on the fact that when a discharge takes place through a non-conductor such as dry air at the moment of discharge the resistance along the line of discharge is practically nothing, and therefore all the charge is conducted away. According to Faraday, "the ultimate effect is exactly as if a metallic wire had been put into the place of the discharging particles" ("Researches," series xii.) Most of those tried failed.

The survival of the fittest has been exemplified in the "plate" protector. In this form—one of the earliest introduced—one thick plate of brass is in connection with the earth, and another similar plate in connection with the line, is placed above it, but separated from it by paper, or by insulating washers. The lightning entering the wire bursts across the paper or air-space in preference to passing through the apparatus, and thus escapes to earth.

An important modification of this plate discharger has been made by Dr. Werner Siemens, who, by serrating, or grooving with a pointed tool the opposing faces of the two plates at right angles to each other, converted them into a conductor which was supposed to be one composed of an infinite number of opposing points. The remarkable action of points in facilitating discharge is well-known, and their introduction into lightning protectors occurred very early in the annals of telegraphy by Mr. C. V. Walker, F.R.S.

Messrs. Siemens's arrangement, very pretty in theory, never carried conviction of its value to the mind of the author, because protectors so prepared never singled themselves out as evidently superior to others that were not so prepared, and while the intersection of the grooves certainly formed mathematical points, they did not form physical or mechanical points, and it is upon the action of this latter kind of points that such remarkable electrical effects are produced.

Dr. Warren de la Rue having very kindly placed his well-known battery of 11,000 cells at the disposal of the writer, he prepared four plate-protectors identical in dimensions, excepting that two were serrated, and two were not. The two plates were separated from each other by narrow ebonite washers ·01 inch thick. The upper plate was placed in connection with the positive pole, and the lower plate with the negative pole. The number of cells were increased until a continuous current of electricity flowed.

1.—*Plain Plates.*

Number of Cells.		Effects produced.
1,000	..	Slight sparks commencing on completing circuit.
1,080	..	Sparks evident.
1,200	..	Sparks frequent and abundant.
1,500	..	Continuous arc.

2.—*Serrated Plates.*

Number of Cells.		Effects produced.
1,000	..	Sparks just commencing on making contact.
1,080	..	Sparks evident.
1,200	..	Sparks frequent.
1,500	..	Continuous arc, but fitful.

2,000 cells in each produced a continuous stream of electricity. The effect with 1,500 cells was decidedly more marked with the plain plates than with those serrated. The experiments were extremely pretty, and very decided in their character. Hence it appears that grooving is not only of no use, but that it rather deteriorates the value of the protector.

These experiments confirm very decidely the accuracy of the figures obtained by Dr. Warren de la Rue and Mr. Müller on the striking distance between two flat disks given by them in their paper read before the Royal Society (*Phil. Trans.*, vol. 169), where it was shown that 1,200 cells struck across ·012 inch. Here 1,000 struck across ·01 inch, which agrees perfectly with the curve produced by those observers.

It is the practice in the Post-office telegraph department to keep these plates apart by thin paraffined paper, ·002 inch thick, so that the air surface is really much thinner than that experimented upon, and the striking difference of potential only 250 volts.

Messrs De la Rue and Müller have shown that for points and various kinds of surfaces opposed to each other, plane surfaces act the best for potentials less than 1,500 volts, and that points are only efficient for high potentials. Now as it is doubtful whether atmospheric electricity causes much higher potential than 1,000 volts, it is clear that plain surfaces are the most effective for protecting apparatus. It is quite certain that such plates, plain and smooth, separated by an air space ·002 inch thick, will form very efficient lightning protectors.

The author is very much indebted to Dr. Warren De la Rue for the performance of the experiments in his laboratory.

* Paper read before the Mathematical and Physical Section of the British Association at the meeting at Sheffield.

THE ELECTRIC TELEGRAPH IN NORWAY.

The first line of telegraph in Norway, according to *L'Electricité*, was opened in 1854, with an extent of only 35 kilomètres. In the quarter of a century which has since elapsed all parts of the country (which measures 316,000 square kilometres) have been covered by the telegraph system. The number of towns and large villages is somewhat small; thus, there are only 227 telegraph offices, and these are nearly all situated in different towns. Christiania is the only city which possesses more than one. One hundred and three of the offices belong to railways, and are worked mostly with the needle telegraph; but they are open for the service of individuals. The Government offices are not all constantly open; 16 are open only during the herring and cod fishery season, and are organised exclusively to facilitate that industry, by warning the arrival of fish. Parliament has a special telegraph office during session. The admission of females into the telegraph service has been the signal of a social revolution,

and they have since been admitted into Government schools, business houses, &c. Though the salaries in the telegraph service are not very high, Norway being a poor country, most of the *employés* belong to the intelligent and educated class, and have studied at the University. The total effective force consists of 450 persons—one director, one surveyor, 11 inspectors, 264 male and 88 female operators, the remainder being students or subaltern *employés*. Two *employés* in the service have the honour to be sent to Parliament, so that the interests of the telegraphic profession are never forgotten, and the service receives all the improvements approved by science and compatible with the resources of a small country, the population of which does not amount to two million inhabitants. The Observatory has a line connecting it with the telegraph system, so that once a month all the clocks are regulated by those of Christiania, and the prevision of the weather takes place regularly. None of the communes receiving the daily announcements are required to pay anything. Candidates for the telegraph service must understand English, German, and French. There is a telegraphic school, where they receive professional instruction after admission to the service. They must have a certificate from the director of the school in order to enter on active duty. The sexes are not separated in the offices, and numerous marriages are the result.

RAILWAYS IN INDIA.

The summary of the annual report by Mr. Juland Danvers upon the railways of India states that an additional length of 995¼ miles had been opened during the year 1878, making a total distance of 8,215 miles, on which traffic is now being conducted. Of the total length open, 6,459¾ miles are on the 5 feet 6 inch gauge, 1,708 miles are on the metre gauge, and 47¼ on the other gauges. Besides lines under survey, there are 1,021¾ miles, of which 231 are on the broad gauge, still under construction. The most important line which has been completed is that along the Indus Valley, which connects the port of Kurrachee in Sind with the Punjab railway at Moultan, and thus, with the exception of the crossing of the Indus at Sukkar, a continuous communication by railway, *via* Lahore, Delhi, Agra, and Benares, to Calcutta, about 2,120 miles in length, is established. A bridge over the Ganges at Benares has been determined on. It will form part of the Oudh and Rohilcund railway system, and will be a very important work both from a commercial and strategical point of view. Some of the native chiefs are showing an interest in railway operations within their territories, and have made arrangements for constructing lines in connection with those existing in their neighbourhood.

The railways in Upper India proved of essential service during the late Afghan campaign. Four thousand men of all arms, in properly arranged proportions, were conveyed from Delhi to Lahore in twenty-four hours, for many days together. By this means 146,000 troops and followers, 15,197 horses, ponies, and mules, 6,227 bullocks, 218 camels, 138 guns, and 33,780 tons of commissariat and other stores were transmitted in 184 special trains during the operations.

The total number of holders of Indian railway investments in England and India on the 31st December, 1878, was 64,321. In this country 25,053 held stock to the amount of £1,000 and upwards, 34,960 held stock of less amount, 771 held debenture bonds, and 3,000 debenture stock, while 220 Europeans and 317 natives were registered shareholders in India. The number of persons employed on the open lines was 142,199, of which 95·15 per cent. were natives of the country, 2·40 were East Indians, and 2·45 Europeans. One European and one East Indian is, on an average, employed in about every 2¼ miles, and to each mile there are 17 natives. The Government of India have given their serious consideration to the subject of educating, in as suitable a climate as can be found in India, the children of the European *employés*, and the railway companies are endeavouring to come to some arrangement for the purpose. The net revenue derived from the railways during the year 1878 was £5,197,815, compared with £6,248,469 of the previous year, and £4,564,823 of 1876. The guaranteed lines earned £5,002,028, compared with £6,117,226. The amount paid for guaranteed interest in respect of the year 1878 was £4,708,134, so that there is a surplus profit of £293,894. There was a falling off in the goods traffic compared with the previous year, but the passenger traffic improved. The movement of grain in 1877 for famine purposes produced an exceptional amount of traffic. The number of passengers in 1878 were 38,495,743, compared with 34,156,791 in 1877; the gross earnings being £3,143,860 and £2,852,973 respectively. The proportion per cent. of first-class was ·651, of second 2·472, of the lower classes 96·877. The lowest class increased from 33,181,971 to 37,326,358; the second from 763,647 to 951,717; the first from 211,173 to 217,668. Upon the whole, the results of the year's working are not discouraging. They have shown that fluctuations in the traffic must be expected according to the state of foreign trade and the internal condition of the country, but that a steady impulse is being given to its staple productions. At the same time, the advance in the passenger traffic, notwithstanding adverse circumstances, shows that the people use the railway freely and largely, if it is brought within their means. It is also satisfactory to find that while the earnings of some lines have fallen short of the guaranteed interest, and others have exceeded it, the aggregate receipts have for the second time covered the amount advanced by the Government.

FIRE-DAMP.

Among the committee reports of the British Association is one on an Instrument for Detecting Fire-damp in Mines, by Prof. G. Forbes. From the rough model shown last year the committee had constructed two new instruments, which appeared to them to answer the purpose of measuring the quantity of fire-damp in a coal mine. The one was of a large size, and was worked by an electric battery. The other was small, portable, easily worked, and it answered all the purposes for which it was required. Both instruments were founded upon the facts that sound travels quicker in light gases than in dense ones, and that air which is contaminated with fire-damp is lighter than pure air. The velocity of sound in different qualities of air was compared by noting the lengths which must be given to a brass tube to cause it to resound to a tuning-fork. The accuracy of the instrument was such that the per-centage of fire-damp could be determined with an error of considerably less than 1 per cent. On the Monday of the week during which the association met, the committee were enabled to descend the Wharncliffe Silkstone Colliery, in the neighbourhood of Sheffield, by the kindness of the manager, Mr. George Walker, who accompanied them with a number of gentlemen interested in the experiments. This pit was at a depth of 200 yards. Mr. Walker had arranged to stop the ventilation and the pit at the end of the workings. After proceeding for a mile through the galleries they reached this spot, where they hoped to find a large amount of fire-damp. But only a slight quantity was to be found, the Davy lamp generally showing but a feeble blue cap, and the Forbes indicator registering only small per-centages. Disappointed here, they were taken by Mr. Walker to another working, where it was thought possible there might be some gas.

In a crevice in the roof a flow of gas was found, forming a stratum of light gas. The instrument indicated quantities which gradually increased, as the tube got filled with the air in the crevice, from 14 to 28 per cent. But the small quantity of gas rendered the experiment unsatisfactory, and the committee were then taken to a disused part of the mine, where it was known there was a blower. Gas in sufficient quantities was found, and the instrument registered gas with more readiness than the Davy lamp. But the greatest quantity registered was 6 per cent., or twelve times the smallest quantity which the indicator detects. There was, in the present form of the instrument, a difficulty in filling the tube with the air of the place under examination, and the committee considered that it would be well to alter the instrument so as to obviate the difficulty. From the experiments they could assert that this instrument was capable of detecting and measuring fire-damp even in small quantities.

VEGETABLE PRODUCTS IN COORG.

From two reports on the produce of Coorg read before the Agri-Horticultural Society of Madras, some idea of the interest attaching to the various crops may be gathered. Rice and coffee are the staple products. The rice crop of last season was looked forward to with great anxiety, and the reporter states that, in the beginning of July last year, when he was on a tour "through the most fertile valleys in Coorg, the paddy fields were dry and none planted, and the ryots lamenting at the long delay of the accustomed monsoon rains; in the middle of the following month, however, the same district exhibited a most cheering sight; everywhere the rice fields were clothed with the most luxuriant and brilliant verdure of the newly transplanted seedlings, and rice cultivation carried on even on the highest fields. It is an interesting spectacle to watch the busy hands of a planting party. The seedlings are plucked by women in the thickly studded beautifully green nurseries, tied up in bundles, and carried to the edge of the fields, where strong arms fling the bundles over the well-ploughed liquid ground. A party of men, arrayed in line, take up as much as they can hold in their left, and with their right hand they swiftly and deftly press a few plants into the soft mud, generally in two lines, and as they have their work before them, they are able, guided only by the eye, to plant as straight as by the help of a stretched rope. All the time the rain is pouring, but the men, stooping and half-knee deep in water and mud, are protected with their tortoise-like, bamboo-framed, and leaf-covered great coats; the women do not take part in this work, they have afterwards the pleasure of weeding." The second staple product of Coorg, namely coffee, had, at the period of the above report, been greatly affected by the long continued drought; indeed, there was no estate in the country that had not a tale to tell of the dreaded *Xylotrechus quadrupes*, which, in some places, had taken such hold of the plants as to almost threaten their destruction. Referring to remedies against this particular coffee plague, the report says "there is nothing more clearly established, especially in the Bambu district, than the fact that judicious shade, freedom from weeds, and digging or manuring are not only the panacea against the 'Borer'—the infested trees being destroyed wherever recognised—but also the sole condition on which certain and increasing profits may be realised." There are in every district of Coorg coffee plantations which answer the highest expectations of the experienced critic, incite to new hope and encouragement, and prove that prudent and patient energy in coffee planting may still cling to this motto, *Nil desperandum*, and have its reward. It is remarkable how observant the natives are of the proceedings of European planters, and how closely they copy, to their own profit, whatever commends itself to their judgment as practical and useful. There are estates, entirely opened out and managed by natives, especially Coorgs, which are in no way inferior to good European plantations. Land, especially in the Bambu district, is still much in demand for coffee cultivation, and sells at high figures.

The various experiments with Liberian coffee do not appear to be encouraging. The plants received from Kew and distributed in small pots by the Mysore Government have not generally done well. Many of them, though transplanted into bamboo baskets and kept in a conservatory, remained sickly, contracted leaf disease, and did not put on a healthy appearance, even after being put out into good, rich soil in the open garden.

In a second report on the product of Coorg, dated on the last day of January of the present year, the same reporter says that the rice-crop was harvested during seasonable weather, and that the out-turn generally was good, in many instances very good. The abundant Ragi crop (*Eleusine coraccana*) in Eastern Coorg, and in Mysore, has told on the market very much, bringing again this staff of life of the Coolies within their reach, to the exclusion of paddy, upon which they do not thrive. The cardamom jungles produced a very fair crop, and with prices risen, considerable profits were expected to be realised. Referring again to Liberian coffee, the reporter says, "I am glad, on further inquiry, to modify my former report. The plant evidently requires acclimatisation to its new habitation, but when once feeling at home, it makes a vigorous start. As an indication of the rate of growth of this plant in Coorg, it may be said that a tree put out as a seedling in 1875 is now 4 feet 6 inches high. It seems that only one tree is in bearing condition, and this has but a solitary berry. All the trees are slender in proportion to their height."

The growth of cinchonas in Coorg would seem to be satisfactory, for it was expected that some extensive plantations would be formed during the present season. As a substitute for mossing, the reporter says he lately observed a peculiar experiment, which to mention, he thinks will be sufficient to deter others from following. The trees being properly barked in strips, the denuded stem was smeared over with clay, &c., tied on with wild cardamom leaves. On removing some clay, the denuded stem was found to be quite dry, for the cambium had fermented, and the formation of bark was consequently hindered, granulation had commenced here and there in irregular lines, but only where the clay did not touch this cambium. The detached leaf-stalks of the plantain ree, and the leaves of the wild cardamom or ginger, tied over the wounded stem, will prove an effective substitute for moss, which, in Coorg, cannot be obtained in sufficiently large quantities.

CORRESPONDENCE.

ABERDEEN WATER SUPPLY.

Having recently visited the Aberdeen Water-works at Banchory, I venture to send you an account which may interest your readers. It has been supplied by an old inhabitant, Mr. Alexander Cruikshank. The water supplied to Aberdeen from 1831 to 1866, was taken from the Dee at Old Bridge of Dee (close to the Tower), where it was filtered through sand and gravel, and then pumped by two Cornish engines, through iron pipes, one and a half miles to a reservoir in Union-place, 140 feet above the sea, from whence the city was supplied by gravitation. Since 1866, Aberdeen has had its water taken from

the Dee, 21 miles above the city, into large reservoirs, and herein filtered through sand and stones. After this, it runs through a close culvert to the low service reservoir, two miles S.W. of the city, and 160 feet above the sea. This reservoir supplies the lower parts of the city. The higher parts of the city get water by gravity from the high service reservoir at Pitfoddels, four miles west of the city, and 396 feet above the sea.

To this reservoir, part of the water from the culvert (above mentioned) as it passes Cutts, is raised by an hydraulic engine, by wasting another part of the water from the same culvert, which is used to drive the engine.

The daily consumption of water has risen from one and a half million gallons in 1850, to four and a half millions of gallons in 1879.

In 1871 the daily consumption was 39 gallons per inhabitant, including domestic and non-domestic purposes.

Aberdeen water contains only 3·65, but London water 21·78 grains of solid matter a gallon. Hardness of Aberdeen water only 1·85, but London water 13·9 degrees. Aberdeen yearly water rate 16d. in 1866, and only 8d. in 1879, on £1 rental.

DAVID G. LAING.

2, Duke-street, Adelphi.

NOTES ON BOOKS.

Annual Record of Science and Industry for 1878. Edited by Spencer F. Baird. New York: Harper and Brothers. 1879.

This is the eighth volume of a series in which the record of scientific and industrial progress has been continued from the time the "Annual of Scientific Discovery" stopped. The contents of the volume are divided under the main headings, ranging from Astronomy to Industrial Statistics, and each subject has been treated by a specialist. The whole is completed by an index, which shows the large range of topics that are described in the book.

Luxurious Bathing: A Sketch by Andrew W. Tuer, with 12 folio etchings, initials, &c., by Sutton Sharpe. London: Field and Tuer. 1879.

This handsome volume, in which some improvements in the art of bathing are pointed out, has been produced in an old-fashioned type, with etched capital letters, and is bound in an antique half-vellum cover. The author gives directions by means of which the greatest enjoyment may be obtained from the "daily tub;" he first treats of the "soap-bath," then of the plunge and the sponge baths, and finally tells what is to be done after the bath. Sea-bathing and swimming come in for their share of attention, and various limits are given to bathers of all classes. The author is an enthusiast for the soap-bath, and claims for it great virtues. He writes, "those who habituate themselves to the indulgence of the soap-bath, become as it were case-hardened, and can seldom be persuaded to forego their daily pleasure, much less to abandon the habit; by its use the body arrives and remains at its highest state of physical vigour; the power of resisting sudden changes of temperature is greatly increased, and liability to cold correspondingly lessened, while there is an almost absolute freedom from danger or infection and epidemic attacks." The illustrations are of river scenes, and the author hopes that the common-place details of bathing will not be considered inconsistent with the character of these etchings.

NOTICES.

THE LIBRARY.

The following works have been presented to the Library:—

Catalogue of Books in the General Library, and in the South Library at University College, London, with an appendix. Vols. 1 and 2. A—N. (London: Taylor and Francis, 1879.) Presented by the College.

Index Society. Publications, 1879. I. What is an Index? A Few Notes on Indexes and Indexers, by Henry B. Wheatley, F.S.A. II. An Index of the Names of the Royalists whose Estates were Confiscated during the Common Wealth. Compiled by Mabel G. W. Peacock. III. Index of Municipal Offices, with an historical introduction by G. Laurence Gomme. (London: Longmans, Green, and Co., 1879.)

Annual Record of Science and Industry for 1878, edited by Spencer F. Baird. (New York: Harper and Brothers, 1879.) Presented by Messrs. Trübner and Co.

Smithsonian Institution. Annual Report for 1877. Miscellaneous Collections. Vols. 13—15. (Washington, 1878.) Presented by the Institution.

The Fishes of India; being a Natural History of the Fishes known to Inhabit the Seas and Freshwaters of India, Burma, and Ceylon, by Francis Day. (London: Bernard Quaritch, 1878.)

Analytical Index to the Series of Records known as the Remembrancia. Preserved among the Archives of the City of London, A.D. 1579—1664. (London: 1878.) Presented by the Corporation.

Copyright and Patents for Inventions. Copyright. (Edinburgh: T. and T. Clark, 1879.) Presented by R. A. Macfie, of Dreghorn.

The Plumber, and Sanitary Houses, by S. S. Hellyer. (London.) Presented by the Author.

Reports of the Metropolitan Board of Works, 1874—78, and Accounts in Abstract, showing the Receipt and Expenditure, 1874—78. (London.) Presented by the Metropolitan Board of Works.

GROSVENOR HOUSE.

The Duke of Westminster is desirous that designers, artisans, and the like, employed in any branch of Art applied to productive industry, should have the opportunity of inspecting Grosvenor House, with its Works of Art, daily, including Sundays, during the months of August and September, 1879, from 2 p.m. to 6 p.m. He regrets that, for want of room, he cannot extend the admission beyond the persons specified.

A number of tickets of admission have been placed in the hands of the Secretary of the Society, for distribution among persons answering to the above description.

Such persons can obtain tickets on application at the Society's house, by bringing with them a paper containing their names, addresses, and occupations.

Each ticket admits a party of four.

There will be no admission on wet afternoons.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," crossed "Coutts & Co."

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,400. Vol. XXVII.

FRIDAY, SEPTEMBER 19, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

PARIS EXHIBITION.—ARTISAN REPORTS.

The selected reports on the Paris Exhibition, made by the artisans who were sent out last year by the Society of Arts, are now in course of publication by Messrs. Sampson Low. They will be published in twelve parts, as follows:—

1. { Pottery and Glass. Part I.
   { Pottery and Glass. Part II.
2. Art Workmanship.
3. Mechanical Engineering.
4. Agriculture and Horticulture.
5. Building Trades.
6. Cabinet Work.
7. Watch and Clock Making, Jewellery and Optical Instruments.
8. Printing.
9. Textile Fabrics.
10. Leather and India-rubber.
11. Mining and Metallurgy.

The reports have been edited by the Secretary of the Society, with the assistance of Dr. R. J. Mann. Although it has been found necessary to omit portions here and there, to avoid irrelevant and needless repetition, great care has been taken to preserve the most distinctive characteristics and the most important conclusions of each writer. The text of the manuscripts has only been altered where this was necessary to correct grammatical errors, naturally incident to the compositions of men unaccustomed to write for the press, and to remove such faults of construction as involved uncertainty and obscurity of meaning.

The price of each part will be sixpence. Twelve copies of any of the parts will be supplied at 4s. 6d. The complete series will also be published in one volume, strongly bound for reference; price 7s. 6d. The first four divisions are now in the hands of the binder, and will be out in the course of a few days. The others will follow in immediate succession.

NATIONAL SCHOOL OF ART WOOD-CARVING.

The Royal Commissioners for the Exhibition of 1851 have now placed a room in the Royal Albert Hall at the disposal of this school, and the school has accordingly moved there, from 3, Somerset-street, Oxford-street. The Drapers' Company have given a further grant, in addition to the grant by means of which the school was founded.

Both day and evening classes are held in the school, under the instruction of Signor Bulletti. The day classes are held from 10 to 1 and 2 to 5 on five days a week, and from 10 to 1 on Saturdays. The evening classes are held from 7 to 9 on four evenings a week, viz., Monday, Tuesday, Thursday, and Friday. The fees for day students are £2 a month, or £5 a quarter. The fees for evening students are 15s. a month, or £2 a quarter.

There are at present 12 free studentships in the school, viz., six in the day classes and six in the evening classes, the fees for which are paid from funds supplied by the Worshipful Company of Drapers. The holders of these studentships are selected by the committee of the school from persons of the industrial class who are intending to earn their living by wood-carving. Candidates must have passed the 2nd Grade Art Examination of the Science and Art Department in Freehand Drawing at least. Those who have some knowledge of wood-carving, or have passed in the other subjects of the 2nd Grade Art Certificate, or in drawing from the antique and the figure, architectural drawing, or designing, or in modelling, will be preferred. Applications for these studentships should be addressed to the Secretary, at the School.

All students are required to provide their own tools, and work done in the schools by free students cannot be taken away. Students paying their own fees may take away work executed by themselves on their own materials, but all work on materials provided by the school remains the property of the school.

Students who have been in the school not less than twelve months may, on the recommendation of the instructor, receive such payment for their work as the committee may determine.

The following gentlemen compose the committee of management:—Lieut.-Col. J. F. D. Donnelly, R.E. (Chairman), Mr. W. Chapman, Mr. R. W. Edis, F.S.A., Mr. W. P. Sawyer, Mr. J. H. Donaldson, Mr. E. J. Poynter, R.A., and Mr. H. Trueman Wood.

For particulars, applications should be addressed to Mr. Healey, National School of Art Wood-Carving, Royal Albert Hall, Kensington, S.W.

HEALTH AND SEWAGE OF TOWNS.

SEWAGE IRRIGATION IN PARIS.

By W. Allen Sturge, M.D.,

Assistant-Physician to the Royal Free Hospital.

During the last few years, when sanitary science has been advancing at so rapid a pace in England, a similar movement has been going on in France, It is true that the French have, in some instances, been later than ourselves in introducing much-needed reforms; but, having once devoted their attention to a subject, the system of centralisation, which is so marked a feature of government in France, has enabled them to bring more power to bear upon the solution of great practical questions than is generally possible in England. The question of the disposal of sewage is a good example of the difference between the two countries. This subject has been a prominent one in England for many years. A large number of methods have been tried in different towns, with a view to avoiding pollution of air or of water, and most of these plans have been abandoned, either on account of their great expense, or on account of their failure to accomplish the object which they were intended to fulfil. Finally, after many years of experimentation, we seem to be solving the problem by establishing sewage farms, and the efforts of sanitary reformers are becoming more and more concentrated upon this mode of disposal of sewage, in the endeavour to bring it to perfection.

In France, on the other hand, the experimentation in this direction has been conducted on a much smaller scale; but, having been once aroused to the necessity for action, the authorities have profited by the experience gained in England, have decided in favour of devoting their energies to sewage irrigation, and have made one of their first attempts at Paris itself. Thus, whilst in England we shall have been the first to adopt sewage irrigation in a variety of localities, and under very different conditions, the French will have been the first to make use of this method for the disposal of the sewage of a town of the largest size.

The history of the introduction of sewage irrigation into France is briefly as follows:—Since the year 1832, a main drainage system on a large scale has been gradually perfected in Paris. Up to that time, numerous drains opened directly into the Seine, with the result that the river, in its course through the town, became greatly polluted. Under the new system of drainage, the sewage has been collected into one great channel, and carried to Clichy, a few miles below Paris, where it is turned into the river. As a consequence of this improvement, the Seine is purified, so far as the town of Paris is concerned; but for many miles below the outlet of the great sewer its condition has become even worse than before, and the numerous towns and villages on its banks, for a considerable distance, have suffered from all the evils arising from the presence of a polluted stream. It was to remedy this evil that the proposal was made, in 1864, by M. Mille, an eminent French engineer, to pour the sewage on to the land, and to purify the water by this means.

The problem presented to the French engineers differed from that which is met with in most English towns, in the fact that at Paris a very small proportion of solid excreta finds its way into the sewers. The solid excreta are, for the most part, received into well-constructed cesspools, which are emptied at intervals, and their contents converted into manure, and thus the quantity of organic matter in each cubic yard of sewer-water is considerably reduced, and the material to be dealt with is consequently more dilute than is the case in England.

The proposition made by M. Mille was to convey the dilute sewage on to some barren, sandy land in the commune of Gennevilliers, within a short distance of the outlet of the sewer, to pour as much of it on to the land as the soil was capable of receiving, and gradually to extend the area thus irrigated, until the whole of the sewage was so disposed of. Operations were begun in 1869, by pumping a few thousand cubic yards of water on to about 17 acres of land; and, though the works were stopped for a time by the Franco-German war, the progress has been steady up to the present time, when about 1,000 acres of sewage-irrigated land are under cultivation. This area is found to be sufficient to purify about one-fifth of all the sewage of Paris; and a plan has been drawn up, and is likely to be shortly carried into execution, for providing the land requisite for the epuration of the remaining four-fifths. There still remain rather more than 1,000 acres in the commune of Gennevilliers, which it is intended to bring under irrigation; and to provide the remaining 3,000 acres, it is in contemplation to pump the sewage through a conduit some miles in length, on to an estate containing about 3,500 acres lying to the north of the forest of St. Germain. This land, which is State property, consists of sandy, unproductive soil, and is at present, for the most part, allowed to lie fallow. In addition, it is hoped that land in the communes bordering upon Gennevilliers, and lands lying in the neighbourhood of the main conduit to St. Germain may be gradually added to that already under irrigation.

There are certain differences between the French method of procedure and that followed in most English towns, where sewage irrigation has been introduced. The first of these is that, in Paris, the town has not bought or rented any one farm for the purpose of irrigation, and with a view to carrying on its own farming operations. On the contrary, the authorities have aimed at inducing independent cultivators to take the sewage for themselves. The few acres with which the experiment was begun were, it is true, bought by the town; but even here the operations were not begun until a number of peasants had agreed to till the land on their own account. Since that time, extension of the area under irrigation has been almost entirely effected by the offers of neighbouring proprietors to take sewage.

The estate at St. Germain, which has been selected for sewage purposes, will, however, be solely in the hands of the town authorities, who will themselves conduct the farming operations. By having a large estate in their own power, their position will be strengthened, because they will then be able to supply to independent cultivators just

such quantity of sewage as they may require, all that is left being carried to their own land at St. Germain; the value of the irrigation will consequently become enhanced, and the demand for it increased. As the value of the sewage becomes appreciated, it is expected that the town authorities will be in a position to ask a fair price for what they supply, and they will thus obtain some return on the money expended over the works.

A second distinction between the French and English methods of irrigation is that at Gennevilliers, in consequence of the sewage being voluntarily taken by a number of proprietors, the land under irrigation is scattered somewhat widely over a considerable area instead of lying all within one boundary fence. The thousand acres are dispersed over an area of nearly three times that extent, strips of non-irrigated land lying between the irrigated fields, a sub-division which is an advantage from the sanitary point of view.

A third distinction is, that in France the epuration of the sewage is looked upon as only a first step towards its complete utilisation. The essential principle of the plan adopted at Paris is that it admits of indefinite extension. In English towns, where a sewage farm is rented by the municipality, the farm stands out by itself as something peculiar from the surrounding farms; there is often a great prejudice against it in the minds of neighbouring proprietors, and, I believe, it very rarely occurs that sewage is carried to other land than that comprised in the farm. This policy of isolation is one which it has, doubtless, been very difficult to avoid, but it is one which brings many evils in its wake. One of the results due to it is that there is little chance of doing more than epurate the sewage. It is well-known that land will absorb and purify a vastly greater quantity of sewage than can be used up by the crops growing upon it. In acquiring a sewage farm, the authorities of towns, with a view to keeping down initial expenses, base their calculations of the amount of land required upon the capacity of land to epurate, rather than upon the capacity of crops to utilise sewage. But it has hitherto been found impossible to pour very large quantities of sewage over lands without the production of more or less scum on the surface, which is difficult to get rid of, and which tends to give a show of reason to the popular outcry against sewage farms on the ground of their unhealthiness. Whatever disagreeable effects may arise from the presence of a sewage farm in the neighbourhood, can be traced to the presence of this scum and of stagnant sewage here and there. This difficulty would be greatly diminished if the sewage could be spread over so wide an area that only such small quantities would be supplied to each acre of ground as would, in the ordinary course of events, constitute the amount of manure requisite to obtain the largest possible crop that the land was capable of producing. Under the system which at present prevails in connection with English sewage farms, it will be almost impossible to bring about this much desired result; instead of a gradual extension of the irrigation works year by year, until the sewage is very generally utilised by the farmers in the neighbourhood of our towns, and bought by them only in such quantities as they may desire, we shall continue to have the one little plot of ground groaning under the rich fare with which it is supplied, and tending to keep up the prejudice already existing against it by the exhalation of effluvia which it will be impossible altogether to avoid.

As I have already said, the system adopted at Paris admits of almost indefinite extension. The sewage being taken by independent proprietors, the rise in the value of the land resulting from its irrigation is evident to everyone. Fresh leases of land recently brought under irrigation, are frequently being drawn up, the rent under the new leases being generally three, four, and even five times as much as that obtained before irrigation was introduced. This rise in price is by far the best argument with which to overcome ignorant prejudices; and thus it happens that one proprietor after another begs to have his land included in the network of conduits. It is easy to see what will be the result of this system. For the complete epuration of the Paris sewage, 5,000 acres of land will be required; for its complete utilisation, not less than 150,000 would be necessary. The saturation of 5,000 acres must inevitably be attended by some disagreeable consequences, the simple manuring of 150,000 could be attended by none. The acquisition of even 5,000 acres by the town authorities would be no easy matter; the supply of the wants of the farmers over 150,000 acres is merely a question of ordinary commerce; and now that the enormous value of sewage as manure is recognised, and proved beyond a doubt by the great increase in the value of irrigated land, it can be only a question of time when an area nearly or quite as large as this is irrigated. Already an offer to take sewage to manure 9,000 acres has been made by the mayor of Méry-sur-Oise, a town lying a few miles to the north-west of Paris, and plans have also been drawn up for the formation of secondary conduits in connection with the great main conduit that is to carry the sewage to St. Germain. These secondary conduits will convey the sewage to various tracts of country in the neighbourhood as the demand arises for it.

At present the whole question of sewage irrigation is in an early stage of development, and epuration only is being attained. The financial results are already almost beyond expectation, but the inevitable results of sewage saturation have followed, viz., the presence of effluvia, and the consequent outcry amongst the inhabitants of the district. Great complaints have been made that, since the introduction of the irrigation, ague has become far more common than it was before, and that more deaths occur from diarrhœa and dysentery. It appears to be pretty certain that ague has increased at Gennevilliers of late years, but other causes have concurred with the establishment of irrigation in producing this result. Chief amongst them is a rise in the level of subterranean water, owing to the construction of a weir a few miles below Paris, which raised the level of the Seine between three and four feet, and thus caused an inundation of the cellars of the houses. The weir was finished just before the irrigations were begun, and if not the sole cause of the production of ague, it has, at any rate, greatly aided the irrigation in bringing about the increased frequency of this disease.

It is difficult to get at the real truth about the increase of diarrhœa. Most of the doctors of the neighbourhood assert that there has been a considerable increase; but Dr. Proust, who drew up a report upon the sanitary condition of Gennevilliers, attached but little weight to the evidence they brought forward. Whether, however, there be or be not a diminution in the healthiness of the neighbourhood, as the result of the saturation with sewage which is at present going on at Gennevilliers, is a matter of only temporary importance; because, as the system becomes extended, and the amount of sewage distributed to each acre is greatly lessened, these evils will disappear. In England, on the contrary, the question is one of very great importance, because of the tendency which now prevails to establish permanent depôts for sewage saturation, and it is one which will, doubtless, attract the attention it deserves. Its further discussion I leave to those who are intimately acquainted with the working of English sewage farms.

THE VENTILATION OF SEWERS.

By John G. Winton.

The furnace system for the ventilation of coal mines has now become obsolete. The plan was a sluggish one, depending on the rarefaction of the air in the furnace or upcast shaft, which was so arranged with those intricate passages in the depths of the earth that, as the rarefied air ascended, another or downcast shaft supplied fresh air to the workings. The suction fan now takes the place of the furnace system. In some instances air is discharged and supplied by these fans at the rate of 100,000 cubic feet and upwards per minute.

Suction fans have been condemned by some authorities as inapplicable for the ventilation of our main-drainage systems. I think differently, that the main-drainage systems of Great Britain have been constructed in ignorance as regards ventilation. Our forefathers, no doubt, did not experience the want of proper ventilation and dilution of sewer gas which now exists in densely-populated cities. Modern works have been constructed, ventilating shafts have been adopted, forming upcast and downcast, according to the locality, nature has been coaxed to aërate these foul receptacles, the sluggish gases have been purified by the charcoal process, and the noxious vapours have been trapped from our dwellings; yet, with all these precautions, very little has been done to create an in-draught into our main sewers, dispersing the vapours from the subways far overhead.

In the first instance, I consider that the sewerage works of towns should be so planned that the low-lying districts are kept separate, as far as practicable, from those of the higher districts; that each district should have a separate sewer, carrying away the sewage and rainfall from that district alone, they should debouch into a main common to all, and should be arranged with large syphon bends, so that the sewer gas of one district may not flow into that of another district; thus I may be able to deal most effectually with the sewer gas. With such an arrangement, I propose drawing the gases out of each district, discharging them into the main common to all, and which eventually would be discharged at the outfall, or made to pass up a chimney, and be dispersed far over head.

Secondly, that all the existing water-carriage plans for the removal of refuse are defective, in the absence of an abundant supply of flushing water directly applied to the main drainage system. I have advocated pumping up sea-water for this purpose for sea-coast towns, and, indeed, for all towns where it could be cheaply and conveniently applied. I consider that, by the application of sea-water, the refuse would be pickled, and would find its way seaward before decomposition took place, and noxious gases were evolved. In all other towns the fresh water supply should be sufficient to meet ordinary requirements, as likewise for periodical or continuous flushing. In the application I have simply considered it necessary to flush the house pipes; and when these tributaries are properly flushed, the mains will likewise be so.

If it is once ceded that continuous flushing is needed for the present system, I consider that a separate system, independent of rainfall, is preferable for the removal of refuse and the effluent water from our dwellings. We should be able to dispense with gullies, and, as there would not be so many air-holes, the gases would be more effectually dealt with. However, there can be no objection to carry away the rainfall, discharging it into the large main already mentioned, which finally terminates at the outfall.

The small jets of water for flushing the pipes leading from the houses need not be more than $\frac{1}{2}$ inch in diameter; the water should be made to spread, striking against the side of the pipe, thus tending to prevent in-draught, and placed in such a position as not to be affected with refuse. For sake of illustration, 4,000 of these jets would represent an area of 784 square inches, or a diameter of nearly $31\frac{1}{2}$ inches; so, with the water delivered under a moderate pressure, as from ordinary cisterns, these small tributaries would eventually create a great rush of flushing water in the mains, the delivery being carefully calculated to suit the requirements.

In some recent examples for the ventilation of sewers, open gratings have been fitted in the middle of the roadways, in connection with shafts leading from the top of the main sewers. Many towns have such an arrangement. These, no doubt, allow the gases to flow out of the mains, more especially when the sewer gases are compressed by a sudden flow of water. In warm weather, with a minimum flow of water through the sewers, the gases rise very sluggishly, and we know the exhalations are very offensive. The "sun" is the furnace, as it were (as in the plan adopted by the early miner), and the sewers being of lower temperature than the atmosphere, the cold air in the sewers rises through the open gratings; hence the various systems for deodorisising the gases by the charcoal process. In the winter months, our houses act as the furnaces; and as we try to make them as snug as possible, by reducing all in-draught through window fittings and doorways to the minimum, the open gratings, fitted to the main sewers, then

act as feeders, sweeping a cold current of air through the sewers, which carries the foul gases along, and eventually rushes through faulty fittings into our comparatively warm dwellings. This must take place at all seasons of the year, and more especially during the night, when we cannot open our windows for ventilation, and when our rooms are at a higher temperature than the atmosphere. However, the more the sewers are properly aërated, reducing the in-draughts into our dwellings, from these noxious receptacles at all seasons of the year, the more healthful will our habitations become. So I am forced to condemn the plain "Roman" system, and advocate the suction fan method adopted by the modern miner.

The furnace system, for promoting ventilation, we all know to be a very expensive plan, unless we can utilise, as in large manufacturing districts, the numerous furnaces under steam boilers. This plan has, no doubt, certain advantages in being able to deodorise the gases, by passing them through the furnace, and then up tall chimneys, where the purified vapours would be wafted away into infinite space.

Next comes the suction fan, driven by the steam-engine. Now, we have a furnace, and at the same time we create a powerful current of air passing into, and drawn out of, the sewers, and then through the furnace and up the chimney to the clouds.

With fans propelled by wind we have a power uncertain and capricious. However, I consider Archimedean screw ventilators could be applied with a measure of success in many small villages where economy may be a desideratum. They are very sensitive; the least wind will cause them to revolve, and with such an apparatus placed on the top of a high chimney, the revolving wheel being six feet in diameter, we should have an engine of considerable power. These machines are fitted with spiral screw blades for creating an upward current. At times the action is feeble; the gases, however, would be kept in motion. In high winds the revolutions are considerable, and the gases would be screwed out of the sewers more rapidly, and instantly dispersed. Gas engines may be used for driving the fan, as some authorities may object to steam-engines and smoke chimneys studded over large and fashionable localities; but when we consider that science has rendered those shafts smokeless, the engine becomes a matter of convenience, and a good gas-engine of moderate power requires less skill on the part of the attendant.

Lastly, we have to consider the turbine or water engine for driving the fan. I have shown that, for the water-carriage system for the removal of refuse, more flushing water becomes imperative, and I propose to take advantage of the effluent water flowing from the turbine to effect a thorough cleansing of our underground netways. And, to satisfy the most fastidious, I propose drawing the gases through an inclosed bed of charcoal of sufficient capacity to suit the requirements.

I will now draw attention to these suction fans. A fan driven by an engine of 20 horse-power discharges 25,000 cubic feet per minute, the suction pipe being 30 inches in diameter, one mile of such a pipe contains 25,872 cubic feet, or a little more than the above fan delivers per minute. The mileage per hour drawn through this 30-inch pipe will be 58, in round numbers, and in the 24 hours 1,392 miles of air are drawn through this pipe of 30 inches in diameter, while the total quantity of air expelled by the machine is 36,000,000 cubic feet in the 24 hours, or, in other words, thirty-six millions of cubic feet would be drawn out of a certain sewerage area, and pure air would instantly fill up the void, pouring into the sewers through existing apertures, or properly constructed inlets. To place these fans in immediate connection with the sewers is impracticable. As the numerous gully holes would act as feeders, and the exhaustive power, at a short distance, would become inoperative, we must lay down a system of piping, so that the sewers may be attacked, and the gases gently drawn out over a large area. Were we to create a sudden rush of air at one part of the sewerage system, even although with no gully holes, we consider the water traps in the house arrangements would be unsealed, and, as we have already stated, the exhaustive power would be limited.

For sake of illustration, I will take a straight length of piping, commencing with 30 inches diameter at the fan. This line of piping should be graduated to a small diameter at the extreme end, of, say, one-sixth of the area, or $12\frac{1}{4}$ inches diameter; the end of the pipe being fitted with a blind flange. This being the main suction pipe, branches are cast on at certain intervals, and pipes fitted thereto in connection with the main sewer, or still smaller pipes in connection with each drain from the houses. These pipes should be smallest nearest the fan, and varying in diameter to the extreme end of the main suction pipe. We consider, that by this arrangement of graduated main and feeders, that the draught would be equalised throughout the entire length of pipe.

When it is desirable to lead a pipe from the main into each house drain, it must be placed between the sewer and the trap, fitted to the drain pipe. These feeders must be small in diameter, so that their combined area does not exceed the area of the suction pipe, as likewise to embrace as many house drains as practicable. For sake of illustration, we will take all the feeders of an uniform diameter of $\frac{1}{2}$ an inch. The area of the 30 inches suction pipe is 706 square inches, and as the area of $\frac{1}{2}$ an inch is ·196, it will require 3,600 feeders to make up the area of the 30-inch suction pipe, or, in other words, 3,600 house drains will be in communication with the suction fan. As the fan discharges 25,000 cubic feet per minute, each feeder would be drawing from the sewers, say, 6·94 cubic feet per minute, or 416 cubic feet per hour. Thus it will be seen that the sewer air would be gently drawn out over the entire area to be ventilated.

We will now assume that a street contains 320 houses to the mile, the houses, of course, being on each side of the street. As there are 3,600 house drains to be ventilated, the total length of the street would be $11\frac{1}{4}$ miles. This shows the capability of a suction fan discharging 25,000 cubic feet of air per minute. We consider this arrangement of small feeders extends the area to be ventilated. Were the feeders one inch in diameter, more air would be drawn through each, but there would be only 900 house drains ventilated, and the mileage would be reduced in propor-

tion. In another arrangement, larger feeders are fitted to the main suction pipe, and placed in communication with the main sewers. These pipes would be placed further apart than the former arrangement, and graduated from a small diameter at the end nearest the fan, and increasing in diameter towards the extreme end, thereby tending to equalise the draught throughout the entire range of piping.

In some situations the main sewers may be of sufficient capacity, so that the suction pipe could be hung from the roof. It should be pierced with holes at certain intervals, which would act as feeders, drawing off the gases immediately over the parts when generated, and we consider all new works should be so arranged when practicable.

In the meantime, we have to deal with existing arrangements. In some towns, steam-power would be preferable for driving the fan, and in other towns water pressure may be adopted. In laying down this proposed pneumatic mode of ventilation, central situations must be chosen. The area to be ventilated we will assume to be four square miles. A powerful suction fan must be erected centrally in that area, and placed in connection with a circular suction box, from which the various suction pipes would diverge. These pipes would be arranged through the main streets and cross streets, in a similar arrangement as for the distribution of gas for lighting purposes, and the feeders carried into the house drains, or in direct communication with the sewers, in the same way as the small gas pipes are taken into our houses. The one system of piping is identical with that of the other; the gas from the gas works is delivered under pressure; the pneumatic method of ventilation supplies air to our sewerage systems, by the exhaustion of a large volume of air drawn out of a system of piping, which, if properly arranged, cannot create negative pressure in the sewers, and which, we consider, would prove a great blessing to the community at large, by the thorough ventilation and purified dispersion of sewer gas carried up high chimneys, far overhead.

THE SUBSTITUTION OF THE PAIL SYSTEM FOR THE PRIVY MIDDEN SYSTEM IN NOTTINGHAM, AND ITS EFFECTS IN REDUCING THE MORTALITY AND SICKNESS FROM ENTERIC AND CONTINUED FEVERS.

By **Edward Seaton, M.D.,**

Medical Officer of Health.

The following paper relates to my experience in Nottingham, during the five years 1873—1877, of the effects produced by the substitution of the pail-closet for the privy-midden system, with regard especially to the prevalence of enteric fever and simple continued fevers, diseases which are grouped together by the Registrar-General under the one heading, "Fever."

I should explain, at the outset, that the circumstances under which Nottingham is placed, as regard its dwellings, are somewhat peculiar, and, as far as I know, without parallel in any other town of about the same size. Previous to 1851, the old town, as it then existed, was confined within very narrow limits, and was described as the most densely built on of any in the kingdom; for, though the borough included an area of nearly 2,000 acres, the greater part had been reserved as commonable lands, and was not available for building purposes. It was not till 1851 that the restrictions were removed, the land thrown into the building market, and the natural growth of the town allowed to take place. The new town, which has grown up around the old one during the past quarter of a century, differs as widely as possible from the older part, to which it is directly contiguous.

The streets of the latter are narrow and tortuous; leading from them are numerous courts and alleys which are mostly *cul de sacs*. The houses consist, in large proportion, of those built on the back to back principle, of which there are about 8,000. It will be easily understood, therefore, that the evils of the privy midden system would be present in their worst form in such a district. Upon the nature of these evils it were unnecessary to expatiate in this place.

It was, then, the peculiar nature of these circumstances that almost forced upon the Health Committee, ten years ago, the adoption of a system of removing excreta by tubs or pails, for the effectual abatement of the nuisances that were so rife. Some trials were at that time made by Mr. Richards, who has for many years been the chief sanitary inspector, and who has paid great attention to this subject, of the working of this plan in a few isolated cases. These subsequently became more numerous as the results proved satisfactory, and so, by very slow degrees, the system became adopted. By very slow degrees, at first, however, as at the end of 1872 there were only 363 closets. Since that time, and during the period to which my own experience relates, the progress has been much more rapid, and at the end of 1877 there were as many as 6,000, including those substituted for middens and those attached to new houses.

Besides fæces and urine, the pails receive the ashes and dry domestic refuse, and in this respect the system differs from that at Rochdale, Manchester, and Birmingham. There being a good agricultural district around the borough, there is no difficulty in disposing of the crude stuff, and as yet there has been no necessity to manufacture manure. The chief reason, therefore, for keeping the ashes, &c., separate, does not exist in our case, and the great advantages of mixing the deodorising and absorbing materials with the excreta are retained.

Let us take now the facts as regards sickness and mortality from fever. For this purpose, I have compared the figures for two periods of five years each—a time sufficiently long to allow for epidemic influence. The returns of deaths, with the exception of those for 1868-1869, which are taken direct from the returns of the district Registrar, are taken from the Registrar-General's periodical returns; those of sickness, from the returns of the General Dispensary, which are the only ones available for the purpose.

The following table sets forth the comparative statement:—

I.—QUINQUENNIAD, 1868-1872.

Population 85,000. *Privy Midden System Prevailing.*

Year.		Sickness. Dispensary. Fever.		Deaths. Fever.
1868	....	113	....	49
1869	....	147	....	47
1870	....	221	....	106
1871	....	137	....	116
1872	....	130	....	77
Total....		748	....	395

II.—QUINQUENNIAD, 1873-1877.

Population 95,000. *Pail Closet System partially taken the place of the Privy Midden System.*

Year.		Sickness. Dispensary. Fever.		Deaths. Fever.
1873	....	104	....	70
1874	....	137	....	45
1875	....	111	....	70
1876	....	123	....	40
1877	....	74	....	31
Total....		549	....	256

The difference is very striking in the total amount of the sickness and mortality for the two periods: it is still more so in proportion to the population. For the first period, the annual mortality was in the ratio of 9·2 per 10,000 of the population. During the second, it was only equal to 5·3, a diminution of more than one-third. The amount of sickness, as evidenced by the returns from the dispensary, was also diminished by nearly one-third.

But, it will be said, have there not been other sanitary improvements progressing coincidently, and are they not of a nature to reduce the mortality? How about your water supply and drainage, and have you not better hospital accommodation, for the isolation of cases of this kind? It would be difficult or impossible to eliminate each of these conditions, and to state definitely to to what extent they may have shared in the results that have been attained. With the exception of the first, there is no reason for attributing any share to the conditions above mentioned.

A great deal of attention has been given to the sewerage, but it has been entirely in connection with its disposal. As regards internal sewerage arrangements, there has been no improvement whatever. In fact, our position in this respect, of late, has not been so good as it formerly was. As regards hospital accommodation for typhoid fever, we are placed now exactly as we were ten years ago, so that both sewerage and hospital accommodation may be set aside.

As regards the water supply, I am not able to speak with equal certainty. The town has been supplied always by a private company. There were but very few private wells, and these, about thirty or forty in number, were closed when the Public Health Amendment Act of 1874 was passed. The public supply was chiefly derived from a source of unquestionable character, but a limited part came from others more or less open to objection. There have been some improvements in this respect. Of the three sources open to objection, one has been discontinued, another only used occasionally, and an additional supply, of the same character as that first mentioned, has been obtained. It is noteworthy, however, that the one questionable source—a well sunk in the bunter beds of the new red sandstone rock, in a populous district—which still remains in use, has been, on good grounds, suspected of being concerned in the spread of typhoid.

On the whole, though improvements in the public water supply may have been the means of diminishing, to some extent, the amount of fever in the district, it has not, I think, contributed very largely to that result.

So far, the facts I have brought forward show a remarkable coincidence between the extension of the pail closet system, and the reduction of sickness and mortality from enteric and continued fever. My knowledge of the other sanitary circumstances of the district leads me to place them in the relation of cause and effect. Moreover, this assumption would be entirely in accordance with the accepted facts with regard to the etiology of this disease, either upon the view of its pythogenic or simple filth origin, or upon the more widely received doctrine of its connection with specific filth-borne germs.

But other facts have come under my observation during the five years referred to, and since, which furnish proof of another kind, and show the dangers arising from privy middens, specially when common to several houses. I will mention two instances in which this was forcibly illustrated, and which formed the subject of a special report by me at the time to the health committee.

There is a yard in the crowded part of the town called Parrott's-yard. There were a block of four privies and a midden, for the use of 19 houses altogether; some of these were in the yard itself, and others back to back in the adjoining street. The people from these latter had to come by a circuitous route to the closets, and to pass other houses which had the use of another block, In 1875, enteric fever was prevalent in the district, and cases occurred in these houses among others. The pit was cleansed and a quantity of strong carbolic powder used. The next year, fever reappeared in the yard, and was limited exclusively to the occupants of the houses using the closets aforesaid. There were in all nine cases, and but little or no illness of the same kind in the immediate neighbourhood. Parrott's-yard stood out as an infected spot, in which the disease was endemic. Again measures were taken for the disinfection of the pit after it had been cleansed. In the summer of the following year a case occurred in the practice of the dispensary to which I am attached, of typical enteric fever, in a child of five years old, in one of these same houses. How far this outbreak might have extended I cannot tell, for immediately steps were taken to compel the alteration of the privies into pail closets, and since that time there have been no more cases. The disease, which appeared to be endemic in this locality, has been literally rooted out.

The second group of cases refers to a little street, known as Snow-hill. In this and the adjoining street, Richmond-street, there were, in 1875, 27 houses using a block of eight privies and a midden of the most abominable construction. Among the

occupants of these houses there were several cases of enteric fever. I cannot say how many, as at the time it was very prevalent in the district, and I received no systematic information of cases.

In November and December of 1876, the next year, there occurred quite a local epidemic in these same houses; among the occupants there were no less than 19 persons attacked, and the remarkable fact was that the occupants of houses situate higher up the street, who had the use of a separate block of pail closets, were free from illness. There was only one case, that of a child who passed much of its time in one of the infected houses.

There were no other circumstances to account for the outbreak. The water was from the public supply, and there was no reason to call this in question, the rest of the neighbourhood supplied from the same source being free. There was nothing to direct suspicion to the milk, the only reasonable inference was that the infected privy pit had been the cause of the mischief.

The case was dealt with summarily. The privy pit was filled up and pails were substituted. In this instance too, we are justified in saying that the disease was eradicated, as since that time, with the exception of two sporadic cases, we have heard of no enteric fever in the district.

[This concludes the proceedings of the Sanitary Conference, held in May last. All the papers read, as well as a report of the discussion, have now appeared in the *Journal.*]

MISCELLANEOUS.

THE IMPORT OF AMERICAN FOOD.

The *Daily News* of the 16th inst. published the following statistical statement on this subject, supplied by Mr. Victor Drummond, H.B.M. Secretary of Legation at Washington:—

Wheat.

Lowest and average prices of Wheat on board at New York, Philadelphia, Baltimore, and Boston, and landed at Liverpool first half-year 1879. *The dollar is equal to 5s.*

Lowest price per bushel on board at New York, 1 dol.; at Philadelphia, 1 dol. 6 cents. to 1 dol. 16 cents.; at Baltimore, 1 dol. 6½ cents.; at Boston, 1 dol.

Average price per bushel of red winter:—On board at New York, 1 dol. 12 cents.; at Philadelphia, 1 dol. 11 cents.; at Baltimore, 1 dol. 6½ cents.; Boston, 1 dol. 6 cents.

Average price per bushel landed at Liverpool:—From New York, common wheat, 1 dol. 17 cents.; red winter, 1 dol. 24 cents.; from Philadelphia, red winter, 1 dol. 18 cents.; from Baltimore, ditto, 1 dol. 27 cents.; from Boston, ditto, 1 dol. 21 cents.

Average freight per bushel:—From New York, 6d.; from Philadelphia, 3¾d., or 7½ cents.; from Baltimore, 6¾d. to 7d.; from Boston, 7½d.

The average price of red winter wheat per quarter landed at Liverpool is then as follows:—Landed from New York, 41s. 4d.; landed from Philadelphia, 39s. 8d.; landed from Baltimore, 42s.; landed from Boston, 40s. 4d. We here observe that wheat from Philadelphia is landed in England at a cheaper rate than from the other ports. The low freight from Philadelphia is the principal cause, and this arises from that progressive city reaping a large share of the trade to Europe. From the 29th of July to the 4th of August over 1¼ million bushels, or more than four times as much as during the same period last year, has been shipped. This steady increase in the grain trade requires a large fleet of ships, chiefly British, which are now flocking to the port of Philadelphia. From information which has reached me, I am led to believe that, under certain conditions, wheat can be delivered at Liverpool from Philadelphia, with a margin for profit, for 35s. a quarter. It is not probable that this will happen, but I mention it as a remote possibility, although it would not be a lasting one.

The total spring wheat acreage sown this year in the United States was four per cent. greater than last year, and the increase will no doubt be as great each successive year, until there are symptoms of no profit in this direction. The yield in the one great wheat State of Minnesota for this year is calculated at 40,000,000 bushels; this is calculating that in two-thirds of its wheat area, 1,900,000 acres, there will be an average yield of 13 bushels per acre; and in the rest of the area, 600,000 acres, the yield will be 17 bushels per acre. The cost of wheat per acre in the great wheat-growing States averages 20s. per quarter.

It is a very different thing in the North-Eastern States, where the farmers are handicapped, as ours are, by the extraordinary low freight charges from the Western States. Again, their farming is carried on partially under the same conditions as our own; they have the advantage, however, over ours, by generally having good-sized orchards, which in a good year bring them in a fair revenue.

The Cattle Trade.

Now, with reference to the cattle trade between England and the United States, I am enabled to furnish some very important information kindly furnished to me by those who are an unbiassed and reliable authority.

New York.—The "prime" beef, wholesale price, has ranged between 9 and 10 cents. (4½d. to 5d.) per lb. For the common quality the price has varied between 7 and 9 cents. (3½d. to 4½d.) per lb. since the 1st of January last. Beeves shipped "alive" to Great Britain will average to cost about 5 dols. 70 cents. per 100 lb. gross weight. The best grades cost more than this, and the fair grades less. The dressed beef "shipped in quarters" costs from 8 to 9 cents. (4d. to 4½d.) per lb. on board in New York, but prime live cattle, for which quotations are made, command, on slaughtering, a better price than ordinary refrigerated meat. The average weight at New York of a "prime bullock" is 1,400 lb., and that of a "common bullock" is 1,100 lb. Average freights per head £3 10s. They have been as low as £2 10s. and as high as £4 15s.

Philadelphia.—Prime shipping are held at 5¾ cents. (3¼d.) per lb. They weigh from 1,250 to 1,500 lb. A beast of 1,500 lb. is landed at Liverpool for £24 10s. Average freight is the same as New York, £3 10s.

Baltimore.—Freight per head to England averages same as New York and Philadelphia, £3 10s., although it has been as high as £4. Cattle landed in England will cost there from 90 dols. to 110 dols. per head, clear of any charges—£18 15s. to £23. The freight on kine from Baltimore to England averaged £4 5s. per head; it was as low as £3 and as high as £5 15s. during this past season.

Boston.—Cattle here are reckoned at so much per lb. living weight. The average weight of each animal sent over is 1,450 lb. 5½ cents. (3¾d.) per lb. is the average price on board. Freight averages the same as the other ports, £3 10s., although it has been as high as £4. Cattle cost, landed in England, on an average £22.

As to the future prospects of the cattle trade between Great Britain and the United States, I think the following points should be known:

If the present restrictions in England on cattle from the United States were removed, and they were allowed to be landed alive, the trade would increase enormously,

and give employment for a large number of British steamers now lying idle; in fact more would be built expressly for the trade. Notwithstanding the present restrictions, and the prejudice created by reports of pleuro-pneumonia and other diseases among American cattle, the shipments from the United States have shown a substantial increase this year. One firm alone in New York sent 2,800 head of cattle the last week of July to Great Britain. Dead American meat is sold in London at 6½d. per lb. at a profit, and it is said that even if sold at 5½d. it would give a small profit.

As long as shippers from New York obtain in Liverpool not less than 7d. or 7½d. for their "prime" beef, so long will a remunerative trade be open to them; but they have obtained readily prices ranging between those given above and 9d. per lb., according to the state of the market. While these prices are obtained, the shipments of American cattle will continue in increasing quantities, for with the vast stock raising lands in the West there is practically no limit to the exportation; and with reference to this I will mention that in 1877 there were 30,500,000 head in the United States, and next year the returns will probably show 35,000,000 head. Last year 86,000 head were landed in the principal ports of the United Kingdom, 67,000 more than in the previous year, mostly from the United States, 30,925 from the port of New York alone to various countries in Europe. It is calculated that England took 24,834, at 92 dols. a head (say, £20 4s.), and Cuba 40,000 head, at 17 dols. each (say, £3 11s.); the wild-grass fed Texans to Cuba, and the shorthorn grades with better feeding to England and Europe; the latter selling for less than five times the price of the former. The weight of the shorthorn grades was about twice that of the Texan. Ten years will, it is stated, bring a remarkable change in the quality and weight of these Texans, and the improvement will possibly be more than enough to supply in quantity the present exports to Europe. Each year probably adds nearly 100 lb. per head to their live weight. Exportation stimulates careful breeding, enhancing the character, quality, and weight of the animal. This improvement in breeding will be equal to an increase of 25 per cent. in number of cattle. Better feeding produces earlier maturity, and, therefore, if 5,000,000 of these are ready for market at two and a half years instead of three years, and 5,000,000 at three years and a half instead of four years, this would give about 16 per cent. more cattle for market each year without increase of the whole number kept.

Oxen are raised in the State of Colorado, and ready for market at a cost of 4 dols. (or 16s. 8d.) per head, and it is claimed that on a large scale it can be done for 3 dols. (or 12s. 6d.) per head. That the United States is destined to supply England with its main supplies of food I have no doubt, for as one of my informants states, first, it is in the very nature of American enterprise to push a trade which affords a profit, and to resort to all manner of "cheapening" processes and methods to make it more profitable; secondly, the extensions of railroads and their facilities into Nebraska, South Missouri, and Texas, all stimulate breeding and increase and cheapen both cattle and their transport to the coast; thirdly, British shipowners will construct vessels with a special view to the rapid and improved conveyance of animals across the ocean, and despite the check caused by the pleuro-pneumonia scare, the traffic will increase. Another gentleman writes from New York:—The cattle dealers here are prepared to work at an even much smaller profit than the present, which they admit is paying handsomely. Even if freight goes up, which is a straw upon which our farmers in England are clinging, I do not think it will help them materially; I imagine that if any brighter look-out arises, it will be from the intense railway speculations going on in the United States, and from the immense sum which must be forthcoming for the renewal of the 80,000 miles of rails already commencing. Will not foreign shareholders require the interest on their money invested, when they find large payments will have to be made for renewal of plant? Will not further capital be required on this account? I only mention this, as it is just possible a rise in transport charges may some day occur, if railway directors find the pressure greater than they can bear.

The United States Treasury Department has recently revoked its order of February last, in which the importation of neat cattle from foreign ports was prohibited; they are now subjected to a quarantine of not less than ninety days under direction of Custom-house officers, and at the expense of parties interested in the shipment.

THE PIG TRADE.—Now let us see how we stand as to our imports of pigs.

From the ports of New York but few pigs have been shipped this year. The price of pork at New York has varied since 1st January from 4 cents. to 6½ or 7 cents. per lb.; but 5 cents. would be a fair average (2½d.). The rate of freight is equal to about 1½ cents. per lb., making the average price in Liverpool 6½ cents. per lb. (3¼d.). The average weight of pigs sent from this port for the European markets is 170 lb. Larger animals are not shipped, being unsuitable for those markets. A pig of 170 lbs. landed in Liverpool would cost £2 10s.

FROM PHILADELPHIA.—Pigs shipped weigh under 200 lb. Their prices range from 4 c. to 4¼ c. per lb. (2¼d.). The freight to Liverpool is 10s. a head, and the pig is landed there for 5¼ c. per lb. (or 2½d.). A pig of 186 lb. would be then landed for the sum of 10 dols. 50 c. (or £2 4s. 9d.).

FROM BALTIMORE.—Pigs landed in England cost, freight included, about 8 c. (or 4d.) per lb. A 170 lb. pig from Baltimore would thus cost £2 17s. 8d.

FROM BOSTON.—Pigs shipped cost 5½ c. (or 2¾d.) per lb., and freight 10s. a pig. The weight of pigs sent from Boston are given at 200 lb. A 170 lb. pig would cost landed in Liverpool £2 9s. 9d.

Pig exports from the United States during the fiscal year 1878 exceeded all other exports of domestic animal products more than 36,000,000 of dollars. Thus:—

PIG EXPORTS, 1878.

	Dols.
Bacon and hams	51,750,205
Lard	30,014,023
Pork	4,913,646
Lard oil	994,440
Live hogs	267,259
Total	87,939,573

ALL OTHER ANIMAL EXPORTS, 1878.

	Dols.
Cattle and cattle products	49,230,366
Horse	798,723
Mules	501,513
Sheep and their products	874,093
All other and fowls	46,841
Total	51,453,536

During the ten months of this present year to April 30th last the value of pig exports appear to have fallen off, owing to the small price they have brought. The quantity, on the other had, was more than 10,000,000 lbs. larger. There was an increase in the demand, but the supply has been so large as to depress the market value.

This year the results from experiments made for the extraction of sugar from the Sorghum plant and Indian corn, and from the beet, will be known, and if any one of these is a success in sugar production and good profits, we may see a diminution in the growth of wheat in favour of the more profitable plants. Canada is also making experiments with the Sorghum cane. The statements given above I have every reason to feel are

correct; if any errors are to be found, they will be so small that they may be forgiven.

Victor Drummond,
H.B.M. Secretary of Legation at Washington.
Kissingen, Sept. 10.

THE AGRICULTURE AND WINES OF PORTUGAL.

Consul Brackenbury states that the development which has undoubtedly taken place of late years in Portuguese agriculture has been due in the main rather to a combination of causes, which has brought more waste land under cultivation, than to any general improvement in the processes of cultivation. Some steps, however, have been made in that direction. There is a central college in Lisbon for the higher education of agricultural students, and the first of a number of projected model farms was established some years ago about five miles from Cintra. This farm occupies a superficial area of 172 hectares. It is intended for the elementary and practical education of farm bailiffs and farm labourers, who, after the completion of an elementary course, are instructed there for a year in the application of steam power to the various operations of ploughing, threshing, winnowing, grinding, &c.; in improved methods of cultivation; in the composition and application of manures in arboriculture; and, generally, in the application of agronomical science to practical agriculture. This model farm is still in its infancy, and is cramped for the want of funds, although the total annual expenses scarcely exceed £3,000. One of the most useful services it has rendered as yet has been the acquisition from abroad of some really splendid animals and birds for breeding purposes.

The Director-General of Commerce and Industry, in a notice on Portuguese wines, calculates the average annual production in Continental Portugal as 4,000,000 hectolitres—a quantity which is probably considerably understated. Of this he considers that rather less than 3,000,000 hectolitres are consumed in the country at the rate of 72 litres per inhabitant; that rather more than 500,000 hectolitres are exported, and rather more than another 500,000 hectolitres are turned into vinegar or distilled. Of the above total of 4,000,000 hectolitres, 1,550,000 are produced in the provinces of Estremadura, Alemtejo, and Algarve. Estremadura, in which the capital is situated, has a superficial area of 1,795,786 hectares, with a population of 836,475 inhabitants. The average annual production is 1,050,000 hectolitres. The wines of this province are held in great estimation, and are remarkable for their variety. Throughout all wine-growing countries almost every parish produces its special wine; but of 93 wines selected as types of Portuguese production for the Paris Universal Exhibition of 1878, no less than 25 came from Estremadura alone. It is these wines naturally which supply the consumption of the capital. Naming those thus employed, the favourites are, Cartaxo, a strong, rough, red wine, much drunk in Lisbon, and exported in considerable quantities to the Portuguese colonies; Torres, a wine something similar to the last character; Collares, which may fairly be called Portuguese claret, is a wine of some delicacy of flavour, and is probably susceptible of improvement; Setubal, a strong, sweet, sound muscatel; and Bucellas, a light, agreeable wine of the hock character, which has long been favourably known in the English market. Other wines of local celebrity, many of which possess real merit, though, as a rule, the processes of vinification are still but imperfectly understood or followed, in regard to the majority of Portuguese wines, are Lavradio, Carcavellos, Termo (white and red Lisbon), and Thomar.

The province of Alemtejo, with a superficial area of 2,441,077 hectares, has only a population of 336,170 inhabitants, and produces annually about 400,000 hectolitres of wine. There was formerly, says the Director-General, a tradition that the Alemtejo was the country of "bad bread and bad wine." This is no longer the case. Some of the wines of this province will bear comparison with those of Estramadura; but the processes of wine-making are here still very defective, and improvements are but slowly and exceptionally adopted.

The province of Algarve has a superficial area of 485,835 hectares, with a population of 177,152 inhabitants, and produces annually about 100,000 hectolitres of wine. The vines in this district were almost extirpated by the öidium, but they have since been renewed, and yield wines which, in body and other natural conditions, resemble wines of the class of sherry, Madeira, and Malaga. Unfortunately, the art of wine-making is in a very backward state in this province, and the wines, as at present made, are for the most part not suitable for the English market. Consul Brackenbury mentions the alternation of droughts and floods, which have had so disastrous an effect on the agriculture of Southern Portugal. The droughts were most severely felt in Algarve—a province which depends in great measure on its fruit and acorn crops. Many thousands of trees perished, and it is feared that years must elapse before the ravages worked by the elements can be repaired.

PHYSICAL FEATURES OF CYPRUS.

Cyprus, seen at a distance from the west, has the appearance of two large oblong islands running parallel to one another in the direction of north-west to south-east. These apparent islands are the two ranges of mountains, which run in that direction, the one along the northern, the other along the southern part of the island, and between which there lies a vast plain, the highest part of which, according to observations made by Dr. Schinas and Mr. Galizia, does not exceed 400 feet above the level of the sea. The latitude and longitude of the chief town, Nicosia, which is situated almost in the centre of the island, is 35° 10′ N. and 33° 23′ E.; and the shortest distances of Cyprus from the surrounding lands, as appears from the chart of the Mediterranean, are as follows:—35 geographical miles from its north-westernmost cape, Kormakita, to Cape Anamur in Karamania; 60, from its north-easternmost cape, St. Andrea, to Latakia, in Syria; 295, from its westernmost cape, Epiphania, or Arnanti, to Cape Xacro in Candia. The distance from Larnaka to Alexandria is 300 miles, and to Malta 960.

Of the two ranges of mountains above-mentioned, the one running along the northern slopes of the island, is called the mountain range of Kerynia, so called after the principal town, bearing that name, in that region, and situated close to the sea. That range of mountains extends from Cape Kormakiti to Cape St. Andreas; its crest is beautifully notched, and the sides rather steep, more especially on the side which looks towards the south. It has no spurs extending from its side to a distance, but only hills or lower ranges clinging to the main chain. These hills, on the northern side, slope gradually down towards the sea, leaving only a narrow plain along the sea-shore. The highest summit of this range of mountains is the Buffavento, said to be 3,240 feet above the level of the sea; and the most remarkable, as to shape, is the Pentedactylon, which bears the resemblance of a hand with its fingers open. The latter summit, according to barometrical observations taken on the spot, is about 2,400 feet above the level of the sea. It is surprising to see on several summits of these mountains, even on those of Buffavento, ruins of churches and monasteries, built of stone, carried up to that height from the plains below. The other range of mountains, which is far higher than the one just described, is that of Troodos or Olympus, the highest

peaks of which, Mount Olympus and Mount Adelphi, are said to be respectively 6,590 and 5,380 feet above the level of the sea. It is in the westernmost part of the island, extending in a direction from N.W. to S.E., as far as Monte Sta Croce. It is not, correctly speaking, one continuous range, but two distinct ranges of mountains, viz., Olympus, properly called, and Maceras; the latter is said to be 4,730 feet high. Although they are, orographically speaking, distinct and separate, yet their direction is such, and the point of junction so imperceptible, as to allow of their being considered as forming but one range. From both sides of that range of mountains, others, of a secondary class, branch off almost parallel to one another, those in the southern slope extending down to the sea, and leaving a narrow and broken plain running along the shore. This mass of mountains and hills forms, on the south-western part of the island, a large mountainous region called Baffo, which for the superior quality of its productions, is far more remarkable than any other district of the island.

The southern side of the mountains of Kerynia, and the northern side of those of Olympus, slope down, gradually in undulated ground, ending in a large plain, which forms the central part of the island. This plain is bounded, on the north and south, by the two ranges of mountains already described, on the west by the Bay of Pendaja or Morpha, and on the east by the Bay of Famagusta. The extreme length of it is about 56 miles. The most fertile part of the plain is 68,639 miles in extent, equal to 439,040 acres. Although one and continuous, it is commonly considered as consisting of three separate parts, each having a particular denomination. The westernmost part is called the plain of Morpha; that in the centre, the plain of Nicosia; and the easternmost, the plain of Messaria. The last mentioned part is the most fertile and the longest; it extends as far as Famagusta, and its name is often given by the inhabitants to the three parts of the plain taken together. This vast plain of Messaria, which both as to extent and to fertility is not inferior to some of the large plains in France and Italy, has been neglected to such a degree, that the traveller is seized by a sense of melancholy at its aspect. In this region of the island whole days may be passed without seeing anything but a dry, wild vegetation, composed for the greater part of thistle and holly, without even pathways. Now and then, and far between, villages are met with of an wretched aspect, partly fallen to ruins, the debris of which obstruct the passage, so as to oblige the traveller to take another direction if he wishes to proceed further. The sight of Messaria is rendered the more gloomy by the absence of any single tree to rest the eye upon.

With regard to the geological structure or formation of Cyprus, the northern range of mountains is composed of compact limestone, and the hills clinging thereto, of chalk and marl, especially in the southern slopes. The southern range of mountains is composed, in its central part, of rocks of the serpentine family, and the spurs, or secondary chains, of chalk. Chalk forms a vast extent of the island; and the lowermost layer of the great plain of Messaria consists of this description of rock. Over this stratum are found two others of conglomerate or pudding-stone, which are met with in all parts of the island visited. The upper layer contains small pebbles, and the lower larger ones, bound together by a cement, which appears to be of a friable and porous nature. Lastly, must be mentioned the downs, which are to be seen over the greater part of the coast of the island, and the sea or littoral drifts. New downs are still in course of formation, and advancing in different localities, especially in the plain of Morpha, part of which has been already encroached upon, to the great detriment of agriculture. It is easy, however, to put a stop to this evil, by the planting of trees, which will check the advance of the drift sand.

The extreme length of Cyprus, from Cape Epiphania to Cape St. Andreas, is 139 miles. The extreme breadth from Cape Kormakiti to the shores of Akroteri, 50; and the narrowest from the anchorage of Ajos Simeon to the roadstead of Larnaka, 27. From the eastern part of the island, a narrow slip of land, comprising the whole Karpas district, stretches out into the sea, in an easterly direction; it is 47 miles long, and of an average breadth of 6 miles. The area of the island of Cyprus is 364,839 miles, equal to 2,334,720 acres; and its circumference, 370 miles.

INDUSTRIES OF THE PROVINCE OF MILAN.

The region of Lombardy, of which Milan forms the commercial capital, is composed of the provinces of Bergamo, Brescia, Corno, Cremona, Mantua, Milan, Pavia, and Sondrio. The silk husbandry is the most important source of Lombard wealth, and forms the centre of an extensive industry which supports a large number of reeling and throwing mills dispersed over the region, while the silk produced is the most valuable article of export, not only for Lombardy itself, but from the whole kingdom. Next in order follows wheat, Indian corn, and rice; of the first and second the yield is generally superior to local wants, of the third there is a considerable export. Fodder is very abundant in the irrigated plains of lower Lombardy; large numbers of cows are therefore kept, especially in the districts of Milan, Pavia, and Lodi, and butter and cheese are made in considerable quantities, and form articles of export. Consul Colnaghi states, in his report, that the production of wine, if sufficient for local consumption in some parts, is very deficient in others, and the quality is very inferior, except in the Valtelline (province of Sondrio), where wine is the chief product, its quality being generally good, and for some growths, such as the "Inferno," "Sascella," and others, excellent. The wines of this district suffer on being carried down to the plain, but improve on crossing the mountains; they are, therefore, generally exported to Switzerland.

The number of industrial establishments, according to information furnished by the Prefect of Milan, that existed in 1874, was 1,271, and the hands employed was 74,328. At the same date, machinery of a total of 9,700 horse-power (potential)—7,303 steam and 2,397 hydraulic—was employed upon the above industries, not including the flour mills worked by water-power, the locomotive engines used solely in agriculture, the railway engines (both locomotive and fixed), and the small amount of machinery existing in the province worked by animal-power. Of the total amount of this machinery, 3,343 horse-power was appropriated to the manufacture of yarns and tissues other than silk, and 3,042 horse-power to the silk industry, the rest being distributed in different proportions among dye-houses, the manufacture of chemical products (645 horse-power), paper, and pottery, iron works, saw mills, and miscellaneous (495 horse-power).

The manufacture of furniture, both of the ordinary kinds and of superior quality, is an important industry in the provice of Milan. The common furniture is nearly all made in the villages of the Upper Milanese, in the district of Monza. The wood used for the outer surfaces are walnut, cherry, and pear; for the linings, poplar and alder. In the town of Monza, tables, chairs, sofas, wardrobes, and other articles are made, and not only of common wood—as was formerly the case—but of fine kinds. In the surrounding villages, makers confine themselves to some special articles—thus, in the village of Mede, chairs, sofas, and the like only are made; at Lessome, beds, tables, *cassettons*, &c. Excepting at Monza, where the furniture is entirely finished, the articles made in the other communes on commission for the Milan dealers are always in the rough, being finished by the whole-

sale purchasers, by whom they are sent for sale in large quantities to the other cities and principal towns of Lombardy, as well as to Venice, Parma, Piacenza, and elsewhere. The furniture made is solid, of good appearance, and cheap. This industry in the territory of the upper Milanese gives employment to some 3,500 operatives, of whom about 500 are boys. Furniture of superior quality is made only at Milan, where articles of all descriptions are manufactured, carving, &c., being largely used in ornamentation. The total value of the production of furniture in the city and province of Milan, may be calculated at not less than from 6,000,000 lire to 7,000,000 lire, of which over 3,000,000 lire are paid in wages. The Milanese makers are now able to supply all demands, and recourse for the best furniture has no longer to be had to Paris; their goods are sold throughout Italy, and exported to foreign countries. The art of painting on porcelain seems to be on the increase; it is cultivated at the female professional school, and there are six workshops for this purpose established in the city of Milan. At Lodi, M. Dosseua possesses a majolica and earthenware factory for making common articles for sale in North Italy, in which about 25 workmen are regularly employed. Artistic works in terra-cotta, statues, ornaments for gardens, and house decorations are made by Messrs. Bono and Airaghi, of Milan. The principal competitors of Italy in this industry are England and Germany.

The manufacture of leather appears to have progressed in the province of Milan since the year 1860, and although it has not yet attained the required degree of perfection, it shows signs of activity, similar to that displayed over all Italy; occasional exportation, indeed, of ordinary goods is made to Austria, and, perhaps to France. The Italian slaughter-houses no longer suffice for the local demand, and hides and skins are imported from the East Indies, from Africa, and especially from South America. The principal ports of imports are Genoa, Trieste, Leghorn, and Ancona. The trade, however, suffers from competition with America, from which country dressed or partly dressed skins are received. In connection with the leather trade, Consul Colnaghi makes mention of the manufacture of gloves. Thirty years ago, the best gloves were imported from Paris, the second qualities from Grenoble and Vienna, and ordinary kinds from Naples. These latter, chiefly straw-coloured lamb skins, were very cheap, easily torn, and wore badly. About this period some Grenoble manufacturers, who had come to Milan with a few cutters and sewers (members of their families), introduced the industry into Milan. Almost at the same date, a dyer from Grenoble opened an establishment for dyeing glove-skins. In a very short time local manufacturers and dyers followed the example thus set, and the industry became successfully developed. The first gloves to fall into disuse were the common Neapolitan; next the Viennese; until, at length, the most improved system of machine cutting having been introduced into Milan by a Grenoble manufacturer, the demand for Paris gloves greatly diminished, and the industry was able to progress without any further need of foreign teachers. In the glove manufacture, lamb skins (large and small) are chiefly employed, the common qualities being made with the first, the better sorts with the second. Kid skins are used for the first qualities only. Italy possesses these skins in abundance. The lamb skins are met with in large quantities in the southern provinces, in Sicily, Tuscany, Emilia, Piedmont, and more or less, in all the regions of the kingdom; the kid skins come from the most mountainous districts of the country, and for Lombardy, from Bergantino, Brescia, and Valtellina. There has been a great improvement in the make of the Milanese gloves during the last few years. They are well cut and sewn, fit well, and wear well. The dyers dye in all colours and of every shade, and the gloves are much sought after, not only in Italy, but abroad. The manufacture of articles in imitation of the so-called Vienna morocco leather ware is carried into some extent at Milan. These articles are made of goat skin and sheep skin—the latter received in large quantities from the provinces of the Ramagna, where it is dressed; the leather is, however, dyed at Milan. The articles manufactured are of the same description as those made at Vienna, such as hand-bags, dressing-bags, and cases of various kinds, purses, pocket-books, &c. The manufacture is inferior to that of Vienna, but being cheaper, there is a large sale at Milan.

Silk is the most important product of the province of Milan, which possesses a large number of silk filatures of various degrees of importance scattered over its surface. In 1863, the total number of basins (*bacinelle*) contained in these mills amounted to 6,449, of which 2,447 were heated by the direct application of fire according to the old method, and 4,202 by steam. In 1871, the number of basins is stated to have been 7,020 (5,830 steam, 1,190 fire. The number of basins in 1878 showed a considerable increase. At the present time, however, the silk industry is greatly depressed, and one-third of the mills are said to be closed, while the remainder are not working at a profit. A greater amount of work is done by the steam basins than by those heated by fire; this is partly due to the first being heated with *batteuses*, and partly because the mills fitted with them are kept open for a longer period. Steam reeling gives a more brilliant silk. The machinery in use in the mills, with the exception of an occasional engine or boiler from abroad, is all made in this country, in some of the large filatures, in great part in the workshops annexed. The latest improvements are carefully attended to. The average day's work in the Lombard mills is from 10 to 14 hours. The reeling season lasts, as a rule, for 170 to 230 days, and even in the most important filatures never more than 11 months; May is always left free to enable the the female hands to attend to the cultivation of the silkworms on their own account or that of others. 50 per cent. of the operatives employed in the silk-reeling industry are women, 45 per cent. girls, and five per cent. men. Wages are stated to be 50 per cent. above what they were before 1860. The increase between 1863 and 1872 is said to have been 10 to 15 per cent., and there appears to be a constant upward tendency. The city of Milan is the head-quarters of the silk trade in Lombardy, and it may be said in Italy. The city "Directory" for 1877 gives the names of 14 cultivators, 32 dealers in and commission agents for silkworms eggs, 43 silk reelers and throwsters, having their offices in Milan, 147 silk merchants and commission agents, 21 silk bookers, and 34 manufacturers of and wholesale dealers in silk stuffs.

The merchants of Milan are active and energetic in general, strongly imbued with protectionist views, and anxious, by all means in their power, to develop local industries. With a view further to extend their trade with foreign countries, and of finding fresh outlets for native manufacture, the Milanese merchants have recently dispatched a commercial expedition, under the command of Signor Malteucci, to the African kingdom of Schoah. From Great Britain large quantities of colonial produce, of manufactured goods, of steel and iron, &c., are imported directly or indirectly to Milan. There are numerous agencies in the city for the principal English manufactures, including agricultural machinery and implements. The city of Milan, the present population of which, with its suburbs, is calculated at about 29,000 inhabitants, forms the centre of a network of railways, placing it in communication with all parts of Lombardy and Piedment; it is connected with the Western Alps on the one side, and the Adriatic on the other, by the main line running between Modane and Venice to the Austrian

frontier, with the Mediterranean by the line to Genoa, *viâ* Alexandria, and with central and southern Italy, by the main line from Piacenza to Bologna, which is the starting point whence the Italian railways branch out along the eastern and western shores of the kingdom. Its railway communications with Germany are, at present, maintained over the Brenner Pass or by way of Geneva, but when all financial difficulties have been overcome, and the great St. Gothard Tunnel is completed, Milan, in about three years time, will have a direct line of her own to central Germany, which will still more increase the commercial importance of the city. During the open season, between May and October, a regular service of diligences is maintained over the Simplon, St. Gothard, Stelvio, and Splugen Passes. A new road is now being made over Monte Tonale to the Tyrol, which will be finished in two years. Steam communication is kept up on the Lombard lakes, Maggiore, Como, and Garda during the whole year.

The province of Milan, which lies on the western frontier of Lombardy, and is separated from Piedmont by the River Ticino, has a superficial area of 2,992 square kilometres, chiefly plain land, and a total population in 1871 of 1,009,794 souls. The province is divided into five districts. It contains 19 provincial roads, of the length of 418,039 metres, and a total length of 4,323,378 metres of communal roads, including mule and bye-paths.

THE TELEPHONE.

The Telephone seems at last to be likely to be brought into practical use in London. The proprietors of both the Bell and the Edison Telephones are starting "Exchanges," systems by which a number of stations are all connected to a central station, and through it to one another. Numbers of their exchanges have been for some time working successfully in America, and in Glasgow the same principles has been applied, but with telegraph instruments instead of telephones.

The *Times* gives the following account of the Edison Telephone Exchange:—"The practical application of the system at present extends to ten stations, all placed in connection with a central station called the Telephone Exchange, which is situated in Lombard-street. The stations, or more properly speaking the private offices, which are connected with the exchange are situated—No. 1 in Copthall-building, No. 2 in Old Broad-street, No. 3 in Suffolk-lane, No. 4 in Lombard-street, No. 5 in Princes-street, No. 6 in Carey-street, Lincoln's-inn, No. 7 in Queen Victoria-street (the offices of the company), No. 8 in George-yard, Lombard-street, No. 9 in Throgmorton-street, No. 10 the *Times* office. At the central office is a switch-board capable of being connected with twenty-four different stations, but which at present is only connected with the ten we have mentioned. The number twenty-four is the most that can be attended to by one person, but there may be any number of switch-boards, in the same room, and any station on one board can be connected with any one on another board. Adjoining the switch-board is a telephonic apparatus, and the operator—who may be a boy—sits in front of the board. Assuming that station No. 2 wishes to communicate with No. 6, the person at No. 2 calls the attention of the attendant at the exchange by means of an electric bell. At the same moment a shutter on the switch-board falls and discloses the number of the applicant. The attendant acknowledges the signal, and No. 2 instantly says, "Connect me with No. 6." The shifting of a pin effects this, and Nos. 2 and 6 are left to communicate with each other. At the close of the conversation No. 2 gives a signal on the bell to intimate that he has finished, and the attendant withdraws the pin and Nos. 2 and 6 are instantly separated. And so with any other numbers; they can be instantly connected or disconnected, and any number of stations can be connected up in couples and worked at the same time. Of course, only one station can be connected with one another at the same time; but the coupling and uncoupling are effected so quickly that a person may communicate with any others in very rapid succession.

"The practical success of all these arrangements must depend very largely upon the possession of a means of communication which meets certain every day requirements. In other words, it means that the transmitting instruments employed must be able to transmit messages clearly, and either in a loud tone, so as to meet the contingency of the receiving party being a short distance from his instrument, or in a low tone, so as to enable a conversation to be be carried on which may be audible to the receiving party, but inaudible to others who may be near and whose ears it is desirable that the conversation shall not reach. The necessary conditions were shown to be amply present, with many others, in the Edison loud-speaking telephone on the day of its trial, the working being in charge of Mr. E. H. Johnson, the engineer, and Mr. Arnold White, the manager, of the company. Loud-speaking this telephone certainly is, but it is none the less soft-speaking also, for conversations were carried on between two parties in whispers, and, although a low hissing sound was perceptible to the bystanders, they were unable to catch the words of the speaker at a distant station. On the other hand, words spoken in a loud tone were audible even, at times, above the hum of conversation. A great many tests were applied by those present in order to prove the system in various ways, but in no case was there any failure, although at some of the stations the operators were quite fresh at the work, and in one or two instances were possessed of rather weak voices. Communications were opened, maintained, and closed with the various stations in rapid succession, and with every success."

The central office of the Bell Telephone Company is in Coleman-street, and they also have a number of firms in similar communication with them.

In Manchester also, shops are being taken to establish a Telephone Exchange, Bell's telephones being employed in this case. It is obvious that there may be many greater facilities for the system in a provincial town than in London, though there can be no reason why even here the experiment should not succeed. It may perhaps eventually prove a disadvantage to have competing systems using different instruments, as it can never be possible, under these circumstances, to connect the two central stations, and thereby enable all subscribers to one exchange to communicate with all those of the other, but at the commencement there are, doubtless, advantages to the public in competition.

The *Electrician* notices a novel application of the instrument; it states that the Children's Hospital at Pendlebury, near Manchester, has recently been fitted with a system of telephones. The lady superintendent's room is thus connected with each of the sick wards, the kitchen, and the pantry. As the hospital consists of six pavilions opening into a long corridor, the most distant pavilion being about 120 yards from the administrative block, it is obvious that much time and labour in running to and fro are saved by this convenient method of communication. It is especially convenient in communicating with the fever ward, thus avoiding the risk of conveying infection to other parts of the hospital.

New forms of the telephone still continue to appear. Prof. Dolbear describes in the *Journal* of the Franklin Institute a form of the instrument which he names the "rataphone" (the meaning of the word is not explained). While experimenting with a common string telephone, with a screw tied to the end of the short string of three or four inches, the screw being made the armature to an electro-magnet in circuit with an Edison transmitter, Pro. Dolbear found that speech was plainly

rendered when the screw adhered to the pole of the magnet, provided that the screw was slowly dragged over it when the variable current was passing. These results led to a new instrument. A short straight bar electro-magnet is furnished with a crank, so that it may be rotated in its coil. Lying upon the poles of this magnet is a bent armature. The back of the armature is fastened to a plate of mica, paper, or thin iron, mounted like similar plates in ordinary receivers, so that any motion of the armature poles is imparted to the plates. Suppose a current of electricity traverses the bobbin, the straight bar becomes a magnet, with strength proportionate to the strength of the current, and the armature will adhere to the poles of it with a certain degree of adhesion. Now let the crank be turned slowly, the adhesion of the armature will result in stretching the plate, and the cessation of the current will permit the plate to regain its former position through its own elasticity. A varying current will result in varying adhesions and consequent vibrations of the plate, and talking may be plainly heard with an instrument constructed thus. There are many ways in which this principle may be utilised. Instead of rotating the magnet, the ends of the armature may be prolonged, and rest upon a cylinder or pulley, which may be rotated, and the varying attractions will cause the diaphragm to vibrate. If a strip of paper be put between the armature and the poles of a common relay or sounder which is in circuit with a transmitter, and the paper be slowly drawn along while an intermittent or vibrating current passes, the ear applied to the paper will hear the sounds, and articulate speech; if the current be varied by such sounds, and if the armature itself be so made as to rotate, the same effects will be produced.

POSTAL REFORMS.

When Rowland Hill had succeeded in obtaining the establishment of a penny postage on the 10th of January, 1840, he had still to silence the opponents of the measure, who pointed triumphantly to the reduction of the revenue of the Post-office caused by the lowering of the rates. He, therefore, had to direct his especial attention to the financial question, and as the old gross revenue of the office was not exceeded until ten years afterwards, he was not able to carry out that part of his scheme which related to the reduction of the rates for foreign and colonial postage. In 1851, however, when the formation of the Great Exhibition had drawn public attention to the advantages of a better system of international communication, a reconsideration of the foreign and colonial postage charges was naturally demanded. An International Postage Association was formed, under the auspices of the Society of Arts, and on the 17th of November, 1852, the deputies from the various Chambers of Commerce, who were in London in conference upon the question of the amendment of Commercial Law, were invited to a breakfast by the Council of the Association in the rooms of the Society. The meeting was presided over by Earl Granville, and among the speakers were Sir John Burgoyne, Mr. (now Sir Henry) Cole, Joseph Hume, M.P., Lord Harrowby, Lord Wrottesley, and Sir Roderick Murchison. At this meeting, the following resolution was carried unanimously:—"That the subject of Colonial and International Postage was one of the highest importance to the commerce and trade of the country, as well as to peace, and to the physical and intellectual improvement of mankind, and, therefore, demands the warm support of every Chamber of Commerce and Commercial Association throughout the country."

On Tuesday, February, 8th, 1853, an extraordinary meeting of the Society of Arts was held to consider a paper by Mr. Yapp, on the reforms proposed by the Postage Association, with Sir John P. Boileau in the chair. An influential deputation waited upon the Earl of Aberdeen, then Prime Minister, in the following April, to urge the question upon the attention of the Government, and after continued agitation on the part of the Association, a reduction in the rates was made. It was announced in August, 1854, that a uniform sixpenny rate of postage had been established for the majority of the colonies, and that in October a similar arrangement would be carried out in respect to New South Wales, Victoria, and South Australia. After this concession had been made, several years passed during which no special anomaly in the working of the Post-office called for public attention. In 1868, however, a very general irritation was felt at the abolition of the pattern or sample post, and the Society of Arts at once took action in the matter by forming a committee for the purpose of "promoting the adoption of reduced rates of postage, particularly in reference to printed matter and parcels." One of the first acts of the committee was the preparation of information respecting the greater facilities for transmission of printed matter through the post enjoyed in Belgium, Brazil, France, and Italy, the Netherlands, Portugal, Switzerland, and the United States. A deputation from the committee waited upon the Postmaster-General (Marquis of Hartington) in March, 1870, for the purpose of urging upon his Lordship the importance of a reduction of the existing rates, and shortly afterwards the Council placed a petition on the subject in the hands of Lord Henry G. Lennox, their Chairman, for presentation to Parliament. In July, of the same year, they further memorialised the Postmaster-General with respect to the *Journal* of the Society, which had hitherto been stitched, but could not, according to the provisions of the new Bill, be registered as a newspaper, unless it was left unstitched. "The Council represent that a good and simple definition of a newspaper will be obtained by the simple condition that it shall be published at an interval not exceeding seven days." Subsequently the Council passed certain resolutions condemnatory of the new regulations, which will be found, with the old and new rules side by side, printed in the *Journal* for October 21, 1870. On the 13th of March, 1871, a Conference was held by the Society on the subject of Postal Reform. The chair was taken by Lord Henry Lennox, M.P.. and Mr. Edwin Chadwick, C.B., the late Mr. T. Webster, Q.C., Mr. A. J. Ellis, F.R.S., and Mr. G. F. Wilson, F.R.S., were among the speakers. On the night of the next day after the Society's petition had been presented in the House of Commons, the Postmaster-General (Mr. Monsell) rose to announce that a new scale of rates for the postage of letters and parcels had been arranged. These are the rates now in operation, and it was generally felt that although the exact terms of the petition had not been complied with, yet a most important and acceptable concession had been made.

POSTED LETTER CERTIFICATES.

The *Times* recently devoted a leading article to the discussion of the value of the system, proposed by Mr. Clifford-Eskell, under which the senders of letters might obtain from the Post-office a certificate of their letters having been posted. The system was fully explained by Mr. Eskell in a communication which appeared in the *Journal* of the 18th April last.

It is proposed that the sender of the letter should be required to fill in the address himself upon the form which he would procure from the office at the cost of a farthing. This form, with the letter, would be handed in to the Post-office. The Post-office clerk would have no other duty than to compare the address written upon the letter with that written upon the form; and, having seen that the two were identical, to stamp the latter with the office stamp of the day, and to return it to the

messenger by whom it was presented. The letter the clerk would put with the other letters posted in the ordinary way.

The *Times*, after a short account of the system, and of the trial which was partly given to it at Liverpool and elsewhere, goes on to remark:—

The circumstances which might render a receipt for a posted letter desirable are almost as various as they are numerous, but it is possible to mention a few of them. There are many cases in which the law admits proof of posting a letter as equivalent to proof of its delivery; and in all these cases, when proof of posting is likely to be required, solicitors and others are obliged to be specially careful in selecting a messenger who is not only trustworthy, but who is also likely to be within reach as a witness at some future time. If a well-arranged scheme were carried into operation, it would, of course, follow that the Post-office stamped receipt would be recognised as a legal document, and then all that would be necessary would be to affix this receipt to any office copy of the letter which was preserved. Again, there are many tradesmen, chiefly carrying on business in London, who every day send numerous small parcels to country customers by post. The customers would object to the extra cost and trouble of registration, the contents of the parcels being generally only of small value. They are sent to the post, perhaps a hundred at a time, by a messenger who, if dishonest, may retain some of them on the chance that the contents may be convertible into beer, and upon whom there is no effectual check. Such tradesmen receive a regular per-centage of complaints of non-delivery from customers, and they have no redress. They cannot tell whether their messenger has been the person in fault or whether the parcels have been lost in the Post-office, or whether a customer may plead non-delivery for the sake of avoiding payment. If they had a book of forms perforated to be torn out easily, and with a line of gum on the back of each immediately to the right of the perforations, they would affix a form to the face of every letter by a moistened corner, and would receive these forms again from the Post-office, duly stamped, and ready to be gummed into a book for preservation and reference. If any inquiry were made about one of the letters which was missing, the Post-office itself could not fail to be assisted by the clear proof of the when and where of the posting which its own proceeding would have supplied. We hear every now and then of servants failing to post letters which have been intrusted to them, and even of office boys destroying letters by the score for the sake of stealing the unused stamps. So often has this been done that many large firms seek to protect themselves by having their initials or some other distinguishing mark perforated upon all the stamps used in their establishments, so that these stamps may be no longer saleable. It will probably be thought that a sufficient case has been made out on the score of the convenience of the public, but the case becomes still stronger when its probable pecuniary results are taken into consideration. There are 14,000 post-offices in Great Britain, irrespective of pillar-boxes; and a daily average of 300 farthing receipts at only 2,000 of these post-offices would yield a revenue of very nearly £200,000 a year. The cost of a fair trial of the experiment would be almost *nil*—would be limited, that is, to the cost of providing forms, which might be as inexpensive as those now used in giving receipts for registration. If the plan were not extensively adopted, it would require no addition to the present staff of the offices; and if it were extensively adopted, it would pay for any addition which might be necessary. It seems as if it would be of unmixed advantage all round; likely to afford increased revenue to the Treasury, increased convenience to the public, and increased facilities to the officials of the Post-office in tracing lost letters. It is, therefore, fair to ask that it should be tried in a thorough instead of in a nominal and perfunctory manner; and, if not generally in the first instance, at least in the place where it is most certain to be used and appreciated—that is, in the metropolis itself. Moreover, the higher authorities of the Post-office might at least be expected to use concerning it the language which a great functionary of the department described himself as using on the introduction of the penny system. "This plan," he said, "we know will fail, but it is your duty to take care that no obstruction is placed in its way." There can be little doubt that a similar course of conduct would serve now, as then, conspicuously to illustrate the accuracy of official foresight, and the value which should be attached to official prophecies.

INDIAN WHEAT.

As regards wheat, India may shortly become one of the chief sources of supply for the United Kingdom. It must be borne in mind that India is one of the largest wheat-producing countries in the world. The production of the United Kingdom amounts to only about 10,000,000 to 13,000,000 quarters per annum. Austria-Hungary, Italy, and Spain each produce about the same quantity. Germany produces from 15,000,000 to 18,000,000 quarters, and the two countries which produce the largest amounts are France and Russia, each producing from 30,000,000 to 35,000,000 quarters per annum. Both are surpassed by the United States, which produced during each of the past two years upwards of 45,000,000 quarters. No complete statistics exist for India, but we know that the Punjab alone produces about as much as the United Kingdom, Oude about 3,500,000 quarters, the Central Provinces about 3,000,000, and Bombay not much less. The production in the North-West Provinces proper has never been estimated, but must be fully equal to that of the Punjab, and that of Behar is also known to be considerable. Thus the yearly production of the provinces under British rule will amount to from 30,000,000 to 35,000,000 quarters, or to the same quantity as that produced by Russia or France. But if the native States in the Punjab, Rajpootana, Malwa, Bundelkund, and Guzerat, be added, in all of which wheat is largely cultivated, it will be found that India must be considered as being, next to the United States, the largest wheat-producing country in the world.

Whilst as regards cotton and some other produce, the soil and climate of India are rather at a disadvantage with those of other competing countries, as regards wheat India is proved to be admirably adapted for the production of the finest qualities of both soft and hard wheat. This is a circumstance of great importance, because the supply of the fine varieties is much more restricted than that of the commoner kinds. In considering the competition in the market of the world, France, although producing as much as Russia, may be left out of account, as its production, large though it may be, barely suffices for its own consumption. Thus, practically, Russia and the United States are the chief competing countries to be considered. But in both countries the area for the production of fine full-grown wheat is comparatively restricted. Spring wheat forms a very large proportion of the Russian supply, as the greater part of the country is too cold for the growth of winter wheat; in the United States, likewise, the climate of Minnesota, Iowa, and the other States on the Canadian border, in which the cultivation of wheat has been recently so rapidly extending, is only adapted for the growth of spring wheat. This wheat, which is mostly red, is not only inferior in quality to a good winter wheat, but it produces also a much lighter crop, not more than 12 to 15 bushels per acre. Thus, however, much the cultivation may extend in these parts, it is not likely to affect the supply of the finest

varieties, such as are grown in some of the older States or in California.

The true policy for India, therefore, appears to consist in taking advantage of her climatic position, and cultivating for export only the finest varieties, in which the competition of Russia and the Far West in America is not likely to be as severe as in the case of the common varieties. Such a policy receives additional recommendation from the fact that the price of the finer varieties is always better kept up, and suffers less in a falling market than that of the common wheat. The higher priced wheat will likewise support better the necessarily high charges of transport and freight. —Dr. J. Forbes Watson, in the *Journal of Applied Science.*

NOTES ON BOOKS.

The Model Locomotive Engineer, &c. By Michael Reynolds. London: Crosby Lockwood and Co., 1879.

The first portion of this book is devoted to a history of the origin of the locomotive, from Murdoch and Trevithick's first efforts, down to the successful establishment of the Manchester and Liverpool Railway. The second refers to a proposal of the author's for certificating engineers and others. Mr. Reynolds would require everybody employed on an engine to hold a certificate, and would have a separate certificate for the engineer, fireman, and engine-boy, each grade being divided into first, second, and third class. Mr. Reynolds is evidently in earnest in his efforts to raise the status of the class for which he writes, and of which he speaks with the knowledge coming from practical experience, he having been himself, as his title page informs us, a locomotive inspector of the Brighton Railway.

GENERAL NOTES.

National Training School of Cookery.—A course of ten lectures on the Chemistry of Food is now being delivered by Professor Church, every Monday at five p.m., commencing Monday last, September 15th. The subjects are:—1. The constituents and uses of food; water, its properties, purity, &c. 2. Starch, sugar, gum, fat, oil, and other heat-givers. 3. Albumen and other flesh-formers, common salt, and mineral matter. 4. A day's ration. 5. Bread and bread stuffs. 6. Peas, beans, and pulse. 7. Potatoes and other tubers and roots, green vegetables and fruits. 8. Milk and dairy produce. 9. Meat, eggs, poultry, and fish. 10. Flavourers, tea, and other food-adjuncts. For further particulars application should be made at the school.

Straw Wood.—A new use for straw in the preparation of an artificial wood is reported from Illinois, United States. Several sheets of ordinary straw board, such as is produced in a paper-mill, are taken, according to the thickness of the desired block, and are passed through a chemical solution, which softens the fibre and saturates it. They are then rolled, dried, and hardened, and emerge from the machine as a compact block, hard, impervious to water, and capable of taking any polish, such as of walnut-wood or mahogany. In fact, on sawing it, it is said to be difficult to distinguish it from real wood. Another application of the same material is reported from San Francisco. Straw pulp is made by pressure in a machine into the form of barrels and kegs, which with their wooden hoops only weigh about 16 lb. The cost of a barrel or a pail is exactly the price of wooden ones, and one man only is required to attend to three machines, which can turn out 750 barrels per day of 10 hours.

The North-East Passage.—Although the sea passage from the Atlantic to the Pacific, along the Asiatic coast, which has been pioneered by Professor Nordenskjold, may never be serviceable as a through route, says *Iron*, there is every reason to believe that nearly every season intermediate passages will be practicable, which will lay open to commercial enterprise extensive regions along the course of the great Siberian rivers, abounding in valuable ores, timber, grain and cattle, hitherto almost excluded from European markets by the difficulties of land carriage. It is to the action of these immense bodies of fresh water that the comparative freedom from ice in this portion of the Arctic Ocean is due, as it is the absence of large rivers, and the existence of numerous islands separated by intricate channels, that renders the north-west passage, if not impracticable, at least wholly unfit for commercial purposes.

Nickel.—The production of nickel has become an industry of considerable importance in Norway of late years. The first mine was opened in 1846 by an English company in the valley of Espedal, in the mountain district of Sondre-Gudbrandsdal, but this was closed in 1857 in consequence of the difficulty of approach and the absence of communications. Subsequently to this, mines were opened at Ringerike and Bamble, near Skien, and from 1861-5 there were eleven nickel mines worked, averaging 3,450 tons per annum. In the latter year the production rose to 5,200 tons from fourteen mines, and it gradually increased until 1875, when it attained its maximum at 34,550 tons. The greater part of this yield is exported in the shape of ore, Norway being the principal source of the nickel supply, and furnishing quite one-third of the yield of the world. A part of the ore is smelted near the mines, averaging between 1871-5 a yearly make of 110,500 kilogrammes. About 465 workmen are employed in nickel mining, though the number has been diminished within the last year or two, owing to the lessened demand.

The Pituri Plant.—A good deal of interest has lately been attached to a singular plant of Queensland and South Australia, known to the people as the Pituri, or, as it has been popularly spelt, pitcheri, pitchourg, or even Billgery. This plant is known to botanists as *Duboisia* or *Anthocercis Hopwoodi*, and belongs to the natural order Scrophulariaceæ. The leaves, it is said, are gathered annually during the month of August, when the plant is in blossom. They are dried, first by a process of straining, and then packing them in hemp bags for purposes of trade. To prepare pituri for use it is damped, mixed with ashes, and rolled up into the shape of a cigar, which the people chew, sticking it during the intervals of chewing behind the ear. The effect of the smoking of this novel cigar is very peculiar, rendering the smoker, for the time being, almost insane when indulged in too freely. When smoked in moderation, the leaves have a powerful stimulating effect, but the symptoms are somewhat similar to those produced by strong drink when taken to excess. The chewing of a small quantity of the leaves is said to assuage hunger, and a person so using them is enabled to undertake long journeys without fatigue and with little food.

Tobacco at the Cape.—Following the example of Jamaica, Cape Colony is taking steps to bring into the markets of the world, in a manufactured state, the supplies of tobacco, of which it is capable of producing such large quantities and so good a quality. The tobacco plant flourishes in South Africa, and considerable crops are reared annually, the produce of which is employed for manufacturing and fumigating purposes. As yet, however, the careless and primitive methods of preparation have prevented the colonists from smoking their home-grown tobacco or home-made cigars, and large quantities are annually imported from abroad. Jamaica cigars are now, thanks to greater care in their manufacture, making quite a name for themselves in the English markets; and there is no reason why the Cape colonists should not, by showing similar enterprise, grow enough tobacco and make sufficiently good cigars to supply at least their own wants, without importing, if not to export a considerable quantity to other countries. An effort is being make to establish a tobacco factory in King William's Town, when every care will be taken to ensure the proper manipulation of the fragrant weed, and to place home-grown produce on an equality with foreign tobacco and cigars.—*Colonies and India.*

JOURNAL OF THE SOCIETY OF ARTS.

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FRIDAY, SEPTEMBER 26, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PARIS EXHIBITION.—ARTISAN REPORTS.

The selected reports on the Paris Exhibition, made by the artisans who were sent out last year by the Society of Arts, are now in course of publication by Messrs. Sampson Low. They will be published in twelve parts, as follows:—

1. { Pottery and Glass. Part I.
   { Pottery and Glass. Part II.
2. Art Workmanship.
3. Mechanical Engineering.
4. Agriculture and Horticulture.
5. Building Trades.
6. Cabinet Work.
7. Watch and Clock Making, Jewellery and Optical Instruments.
8. Printing.
9. Textile Fabrics.
10. Leather and India-rubber.
11. Mining and Metallurgy.

The reports have been edited by the Secretary of the Society, with the assistance of Dr. R. J. Mann. Although it has been found necessary to omit portions here and there, to avoid irrelevant and needless repetition, great care has been taken to preserve the most distinctive characteristics and the most important conclusions of each writer. The text of the manuscripts has only been altered where this was necessary to correct grammatical errors, naturally incident to the compositions of men unaccustomed to write for the press, and to remove such faults of construction as involved uncertainty and obscurity of meaning.

The price of each part will be sixpence. Twelve copies of any of the parts will be supplied at 4s. 6d. The complete series will also be published in one volume, strongly bound for reference; price 7s. 6d. The first four divisions are now in the hands of the binder, and will be out in the course of a few days. The others will follow in immediate succession.

TECHNOLOGICAL EXAMINATIONS.

The City and Guilds of London Institute for the Advancement of Technical Education have just issued their Programme, for 1880, for the Technological Examinations which were transferred to them by the Society of Arts. The subjects in which it is announced that an Examination will be held are as follows, those marked with an asterisk (*) having been added this year for the first time:—

I. Alkali Manufacture.
II. Blowpipe Analysis (Practical).
III.*Brewing.
IV. Calico Bleaching, Dyeing, and Printing.
V. Carriage Building.
VI. Cloth Manufacture.
VII. Cotton Manufacture.
VIII.*Electro-Metallurgy.
IX. Gas Manufacture.
X. Glass Manufacture.
XI.*Goldsmiths' and Silversmiths' Work.
XII.*Iron Manufacture.
XIII.*Lace Manufacture.
XIV.*Manufacture of Oils, Colours, and Varnishes.
XV. Paper Manufacture.
XVI. Photography.
XVII. Pottery and Porcelain.
XVIII.*Printing.
XIX. Silk Manufacture.
XX. Silk Dyeing.
XXI. Steel Manufacture.
XXII.*Sugar Manufacture, &c.
XXIII.*Tanning Leather.
XXIV. Telegraphy.
XXV.*Watchmaking.
XXVI. Wool Dyeing.

It will be noticed that ten new subjects have been added, in addition to the sixteen included in the Society's programme of last year.

The conditions under which Examinations will be held are as follows. It will be seen that some considerable modifications of the Society's original scheme have been made.

The City and Guilds of London Institute for the advancement of Technical Education will afford facilities for carrying out an Examination in any of the subjects, wherever a class for instruction is formed, or a sufficient number of candidates present themselves, provided a Local Committee undertakes to carry out the Examination according to the rules laid down.

The Committee of any Art or Science School under the Science and Art Department, or any School Board, or any "Local Examination Board" connected with the Society of Arts, will be accepted as a suitable Committee for carrying on the Institute's Examinations. In special cases, also, the Committee of the Institute may entertain propositions for the establishment of Special Local Committees for the Technological Examinations.

The Examination will be in three Grades:—

I.—Honours.
II.—Advanced.
III.—Elementary.

Grade I. is intended principally for foremen, overlookers, &c.; Grade II. for journeymen; Grade III. for apprentices; but candidates may enter themselves for any grade they choose. Certificates (First and Second

Class) will be awarded in each grade. Candidates who have taken a certificate may be again examined for one of a higher grade or class in another year.

Any person desiring to be examined may present himself, but before he can take a certificate in Technology he will be required to have passed the Science and Art Department Examination in certain Science subjects. The Science subjects required for each Technological subject are given in the syllabus of each subject. Candidates who have previously passed the required Science subjects will receive a full Technological Certificate on passing the Examination in Technology. Candidates who pass in Technology alone will receive a preliminary certificate, which will be exchanged for the full certificate whenever the candidate passes in Science. There is no limit of age. Intending candidates should apply to the Secretary of the nearest Local Committee, who will forward their names to the Central Office in London, and through whom all information will be furnished. It is only in the case of candidates failing to make arrangements with the Local Secretary that any application can be considered by the Central Office.

The Examinations are conducted by means of printed papers, and the answers are written upon paper specially provided for the purpose. The papers are sent down in sealed envelopes to the Secretary of the Local Committee immediately before the day of the Examination, and the envelope containing the papers is opened by a member of the Committee, in the presence of the candidates, on the evening of the Examination. A number is allotted to each candidate, and he is known to the examiner only by that number. The worked papers are sealed up at once, and despatched to the office of the Institute. The certificates and prizes will be forwarded to the Local Secretaries as soon after the Examination as possible. No application on the part of any of the candidates is therefore necessary.

The Examination in Blowpipe Analysis being purely practical, is conducted by means of specimens sent to the examination centres. For information as to this Examination, reference should be made to the syllabus.

Payments to teachers of Technological subjects, on the results of instruction in Technology, will be made, generally in accordance with the same rules as the payments made by the Science and Art Department to Science teachers.

Secretaries of local committees will also be paid a fee of 1s. on each candidate passed at their Examination.

The Examination for the year 1880 will be held in May, on the same evening as is fixed for the Examination in Nautical Astronomy by the Science and Art Dement.

Local Committees.

Each Local Committee must consist of at least five members, and must have a chairman and a secretary. No member or officer of a Local Board can be admitted to Examination.

The duties of the Local Committees are:—

(*a.*) To give publicity to the system of Examinations, by the circulation of programmes, posters, &c. (copies of these will be furnished gratis on application), and to give encouragement and advice to those persons who are likely to become candidates.

(*b.*) To superintend the Examinations. Instructions for conducting the Examinations will be sent to the Secretary previous to the date on which the Examinations are held.

(*c.*) To aid in the formation and watch the progress of classes for instruction in Technology. To visit such classes occasionally, and examine and sign the register.

Grants to Teachers.

1. These grants will only be made on account of persons engaged in teaching Science or Art Classes under the Science and Art Department, or of persons who have passed in the Honours grade of the Technological Examinations in the subjects to be taught.

2. They will consist of £2 for each candidate taking a First-class, and £1 for each candidate taking a Second-class in any grade in the Technological portion of the Examinations.

3. The students, on the result of whose Examination the grants will be made, must be persons actually engaged in the industry to which the Examinations refers, or in some closely allied industry. They will be required to obtain their employer's signature to a form testifying to this fact. This rule, however, does not apply in the case of the Examination in Blowpipe Analysis.

4. Any teacher desiring to form a class for instruction in any Technological subject should apply to the Secretary of the Institute, Mercers'-hall, E.C., as early as possible, stating his qualifications. If approved, his name will be registered, and no payment will be made to any teacher whose name is not so registered.

5. To obtain a grant on account of the success of any candidate, the teacher must have given that candidate at least twenty lessons in the subject, of not less than one hour each.

6. The lessons must be *bonâ-fide* lessons in the Technological subject, and no payments will be made on account of lessons in a kindred Science subject, by which grants are earned from the Department.

7. Payments will not be made twice on behalf of the same candidate, unless he takes a higher class or grade.

8. The Institute reserves the right of refusing the application of any teacher to form a class for instruction in Technology, or of withholding the grant, if they should see fit to do so.

9. This offer only holds good till May, 1880, and may be revoked or modified after that date.

10. The claim for payments must be made on a form which will be supplied to the Secretary on application. This form must be signed by the Chairman and two Members of the Committee at least, and countersigned by the Secretary.

11. A register of attendances must be kept by the teacher, on a form which will be supplied on application. This form, which must be vouched for as accurate by the Committee (see *c* above), has to be returned with the claim for payment.

Prizes.

The following will be given in each subject:—

Honours ..	1st Prize, £5 and a Silver Medal. 2nd Prize, £5 and a Bronze Medal. 3rd Prize, a Bronze Medal.
Advanced -	1st Prize, £3 and a Silver Medal. 2nd Prize, £3 and a Bronze Medal. 3rd Prize, a Bronze Medal,
Elementary	1st Prize, £2 and a Silver Medal. 2nd Prize, £2 and a Bronze Medal. 3rd Prize, a Bronze Medal.

No First Prize will be awarded to any candidate obtaining less than 85 per cent. of the full marks, and no prize to any candidate who does not take a First-class Certificate.

The programme also contains syllabuses of the different subjects, and a reprint of the last examination paper set in each subject.

Copies of the Programme can be had gratis on application to the Secretary, City and Guilds of London Institute, Mercers'-hall, E.C., or to the Secretary of the Society of Arts.

SELF-ACTING INTERMITTENT SIPHONS, AND THE CONDITIONS WHICH DETERMINE THE COMMENCEMENT OF THEIR ACTION.

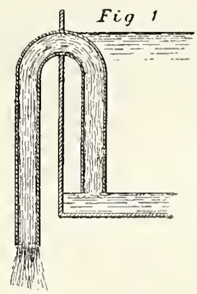
By Rogers Field, B.A., M. Inst. C.E.

In the discussion on Mr. Barlow's paper on the upward jets of Niagara, read at the Plymouth meeting of the Association, I made a few remarks with reference to an improved form of self-acting siphon I had invented, the action of which depends on the power of falling water to drag air along with it, and I now, by request, will give a description of the action of this siphon, illustrated by a working model.

Before proceeding to describe the peculiarities of this siphon, it will be well to say a few words generally as to self-acting siphons employed for the intermittent discharge of fluids from vessels. The idea of employing siphons in this way is by no means new, and I may instance the philosophical toy, called "Tantalus's cup," which many of us have seen in our youth. In this cup there is a concealed siphon, which is brought into action when the cup is raised to the mouth to drink, so that the water sinks away from the lips and cannot be drunk. A self-acting siphon has also been employed for emptying vessels used for measuring water, as in Osler's and Bickley's self-recording rain gauges, as well as on a large scale for reservoirs.

The chief difficulty to be overcome in applying syphons in this way is to start them or put them in action. In an ordinary siphon, such as that shown in Fig. 1, the siphon will not be put into action unless the

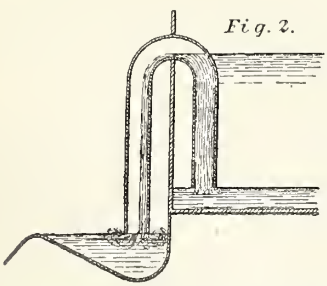
Fig 1



water in the vessel rises above the top of the bend of the siphon, and it will be readily seen that if the siphon is any size, this will require a large accession of water in the tank, so that the siphon will not work except in cases where there is a large flow of water.

This difficulty can, to a considerable extent, be overcome by dipping the outer leg of the siphon in water, as shown in Fig. 2. The water which runs over the bend

Fig. 2.



* Paper read before the Mechanical Section of the British Association, at Sheffield.

of the siphon will then drag a certain quantity of air with it, and drive this air out at the lower mouth of the siphon, and as the air cannot return in consequence of this mouth being sealed, the air in the outer leg is gradually reduced in tension below the atmospheric pressure. Whether this partial exhaustion of the air in the outer leg is sufficient to start the siphon, depends on the quantity of water that runs over the siphon, but the quantity required will be much less than if the outer end were open, and it will not be necessary for the water in the vessel to rise above the top of the bend of the siphon.

Although the expedient of dipping the outer leg of the siphon in water greatly reduces the quantity necessary to start the siphon, the required quantity is still very considerable if the siphon is of any size, and further expedients have therefore been adopted to reduce this quantity. One of the simplest of these expedients is to have two siphons of different sizes connected together by a tube at the crown, and so arranged that the water runs through the smaller siphon first. The outer ends of both siphons are dipped into water, the smaller siphon then starts with a comparatively small quantity, and afterwards by means of the connecting tube exhausts the air from the larger siphon, and brings it also into action. This method was adopted by Professor James Thomson, F.R.S., in 1860, for his jet pump, and it was also carried out on a large scale in France in 1867, at the Reservoir do Mettersheim. In this latter case, there are two siphons of about 28 inches in diameter, each of which is put into action by a smaller siphon of 6 inches in diameter.

This expedient, however, and several others which have been adopted, leave much to be desired, as they are to a certain extent complicated, and yet do not sufficiently reduce the quantity required for starting the siphon to enable it to be used in many cases. The method which I am now about to describe is both simpler and much more effective.

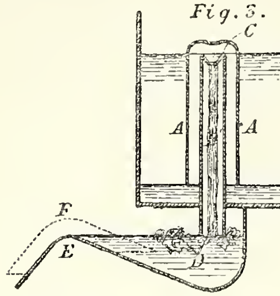
In an extensive series of experiments which I tried some years ago on siphons, with their outer legs dipped in water, I was much puzzled by finding that the quantity of water necessary to put a siphon of given size into action varied in the most unaccountable way at different times. The only difference that could be perceived between the cases in which the siphon started and those in which it did not start was, that in the former case air-bubbles escaped freely at the mouth of the siphon, whereas in the latter case, under apparently the same conditions, very few bubbles came out. At last the idea suggested itself to me of making a portion of the siphon in glass, so as to see what was going on inside the pipe, when the course of the irregularity was at once discovered. Sometimes the water which ran over the bend adhered closely to the sides of the pipe, at other times a portion of it would fall more or less clear of the sides. When the water adhered to the sides it produced very little effect in displacing the air, so that only a small quantity of air was driven through the water at the mouth of the siphon. When, on the other hand, the water fell clear of the sides, it produced a great effect in displacing the air, and large bubbles of air at once escaped from the mouth of the siphon.

I pursued the investigation further, by producing artificial irregularities in the pipe, and I then found the more completely I could throw the water clear of the sides of the pipe, the greater effect it produced in expelling the air and starting the siphon. The form of siphon which I have finally adopted as most effective is shown in Fig. 3, and in a working model.

The siphon consists of two concentric tubes, A and B, the outer one, A, being closed at the top, and steadied and supported by three radial ribs projecting from the inner tube, B. The annular space between A and B constitutes the ascending or shorter leg of

the siphon, and the inner tube, B, the descending or longer leg. At the upper mouth of B is fixed a conical shell, C, projecting inwards clear from the inner surface

Fig. 3.



of the tube, B. The lower mouth of B dips into a discharging trough, D, which has a weir, E, level with this lower mouth. The action is as follows:—When the vessel is full, the water begins to trickle over the edge of the conical shell, C, and is so directed by the shell as to fall towards the centre of the tube, B, quite clear of the sides, thus producing the maximum effect in displacing the air. The action of the siphon soon commences, and continues till the water in the tank is lowered to the level of the lower mouth of A, after which air is admitted by that mouth to the siphon, and the action ceases.

In some cases, the quantity of air admitted at the end of the discharge, though sufficient to stop the siphon, is not sufficient to fully charge it with air, so that the next discharge will commence before the water in the vessel has risen to its full height. To obviate this, the best expedient is a secondary siphon, F, fixed in the trough, D, and put into action by the discharge from the larger siphon, A B. When this discharge has stopped, the syphon, F, continues in operation, so that the water in the trough, D, is drawn off, the lower mouth of the pipe, B, unsealed, and the larger siphon fully charged with air. Presently, also, the action of the secondary siphon, F, is also stopped by the admission of air. When the vessel is filled, and water trickles over the shell, C, the trough, D, is again filled up to the level of the weir, and the siphon, A B, becomes sealed.

There are other minor conditions which affect the commencement of the automatic action of the siphon, such as the roughness of the top of the conical shell, C, the ratio of the area of the tank to the area of the siphon, the length of the siphon, &c., but these I will not go into.

In conclusion, it is evident that the above form of self-acting siphon will be of great practical use for a number of purposes. I will merely mention one, viz., that of flushing sewers, by means of small quantities of water which ordinarily runs to waste. Take, for instance, a drinking fountain, the water which escapes from it is, under ordinary circumstances, absolutely useless for flushing purposes. Collect this water, however, in a tank with a large self-acting siphon, and as soon as the tank is full, be it in one day or in several days, the siphon will be brought into action, and the contents of the tank discharged with great rapidity. The trickle from a drinking fountain would start a siphon of as much as ten or twelve inches in diameter of the improved form, and would, therefore, flush a sewer of considerable size, say, nearly three feet in diameter.

A new telegraph wire, especially applicable for military lines, is being made and tried in Germany. It consists of a compound iron and aluminium wire, combining lightness with strength and conductivity.

TECHNICAL EDUCATION IN RUSSIA.

One of the principal establishments for technical education in Russia is the industrial school of the Czarevitch Nicolas, at St. Petersburg. This school, which bears the name of the late heir to the throne of the Russias, the Grand Duke Nicolas Alexandrovitch, is an establishment of a character which has not found much favour in our own country, combining general education with instruction in everything connected with scientific and manual industries. It originated in the benevolence of private individuals, who founded first an asylum for poor children destined to become artisans. The society obtained royal authority to open other similar establishments, and it has founded an industrial school for girls on the same principles as the preceding. The society and its foundations are placed under the patronage of the present heir to the throne of the Czar, the Grand Duke Alexander Alexandrowitch, who subscribes three thousand roubles annually towards its funds. The idea of the establishment of such a school in the capital of the kingdom was taken up very warmly; the members of the society already referred to gave 200,000 roubles for the construction of the building, and the merchants of St. Petersburg and others supplied more than 30,000 roubles. During the construction of the school, which occupied three years, the Municipal Council of the capital made an annual grant of 25,000 roubles, and the Government gave the site for its erection and a sum of 75,000 roubles. The value of the whole, as it stands, is set down at 175,000 roubles. The liberality in the supply of money enabled the architects and organisers of the school to pay special attention to the arrangements, not only for the instruction, but for the health of the pupils; and the lighting, heating, and ventilation of the building are considered eminently satisfactory.

The school was opened in 1875, with the three lower classes only, but the number was soon afterwards raised to five, according to the original scheme. Last year the number of pupils was 240, and that of professors and teachers 24. Twelve of the pupils are maintained at the cost of the Grand Duke, and one at that of the Grand Duchess. The authorities of the city maintain 100 pupils at the cost of 25,000 roubles per annum (£3,400 nearly); and the original society supports 38 other pupils. A few of the others are maintained by the establishment itself or some of its individuals, others by governmental departments, and the rest by their parents and friends, who pay 250 roubles per annum (about £32).

This establishment is capable of receiving 300 pupils, all resident; there are no day scholars. The total expenses of the school, with the full number of scholars, would be 95,000 roubles.

The boys are admitted to the lowest class at the age of 11, those who are older are examined, and may be admitted to either of the three lower classes.

The instruction includes:—

1. Catechism and sacred history, the Russian language, arithmetic, geometry, history, natural history, geography, physics, mechanics, and the technology of wood and metals.

2. Freehand and mechanical drawing, writing, singing, and gymnastics.

3. Trades.

The programme of studies is arranged by a committee composed of the heads of the establishment, and secular representatives of the arts, sciences, and education.

The general instruction is strictly limited to that which is considered to be necessary for the intellectual, moral, and sanitary requirements of artisans, carried on in such a manner as to inculcate theoretical knowledge with the aid of practice, a method which the directors believe to contribute effectively to the intellectual and moral development of the pupils.

The amount of time devoted to the various studies is fixed as follows:—

The five classes of instruction occupy sixty-nine hours per week, 21 being devoted to the Russian language, 14 to arithmetic, 9 to catechism and sacred history, 8 to geometry, 5 to history, 4 to geography, 5 to writing, and 3 to natural history. In addition to the above, 9 hours are devoted to special instruction in physics and mechanics, 4 hours to the technology of wood and metals, 5 hours to singing, and 6 to gymnastics; making up a total of 89 hours per week.

Besides the above subjects and exercises, drawing, of course, fills a prominent place; to it are devoted 41 hours in each week, by the five classes. After an elementary course, the pupils draw from geometrical solids and plaster casts, and execute special designs for furniture and wood carving. The course of mechanical drawing includes a section specially adapted to iron workers, and mechanicians. The instruction in drawing terminates with working drawings belonging to the various trades taught in the school.

The industrial instruction is confined to the three upper classes of the school, and ordinarily occupies 20 hours per week, but the two weeks preceding the holidays are exclusively devoted to work in the various ateliers of the school, which include shops for cabinet-making, modelling, turning, wood carving, fine iron-work, metal turning, soldering, forging, and fitting.

The instruction in the workshop is on a very methodical plan, including the teaching of the elementary data, as well as the special processes of each craft. Correct and precise work, and the proper employment of tools, are the objects in view. Orders are executed in the workshops and ateliers, but no pupil is permitted to execute such work until he have passed satisfactorily through all the prescribed courses of study and instruction.

When the pupils have completed their studies, they may remain one or two years longer in the school, to perfect themselves in any one of the crafts, and obtain the title of apprentice-workman; this extra time is devoted exclusively to work.

On quitting the school, each pupil receives a certificate, and those who have passed with great credit through their examinations earn the titles of foremen and assistant-foremen, and obtain assistance to enable them to establish themselves in business, or to complete their industrial education and practice.

The Director of the School is Professor Nicolas Labsine, and the President of the Committee of Instruction is Professor Jean Wyschnegradsky, Director of the Technological Institute of St. Petersburg. The school was only established in 1875, so that its first results will appear in the present year.

The industrial institutes, schools, and museums of St. Petersburg and Moscow made a very remarkable show in the machinery court at the Paris Exhibition last year. The extent of the collection of diagrams, models, and other educational material, and the admirable execution of a large number of tools, machines, and models made by the pupils in these establishments attracted much attention, the unavoidable inference being that the Russian Government and people are intent on raising the industrial and artistic level of the population as much and as rapidly as science and organisation can effect.

A new oil plant, says *Nature* (*Lallemantia liberica*) has been acclimatised on the fields of the Agronomical School at Cherson (South Russia). It belongs to the *Labiatæ* family, and is very similar to *Dracocephalum*. The herb attains a height of 1½ to 2½ feet, and bears some 2,500 seed-grains, which give a very pure oil, applicable even for culinary purposes. The seeds of this originally Persian plant were first sent to Cherson by Prof. Haberlandt, of Vienna.

COTTON CULTURE IN CYPRUS.

The cotton of Cyprus belongs to the species called "grassy cotton" (*Gossypium herbaceum*). There is also some "Nankeen," but very little, and it is of a chamois colour (*Gossypium hirsutum*), while lately there has been introduced from Egypt the "Bamia" cotton, which thrives very well in the island. Cotton is sown in alluvial soils, no matter whether they be inundated or not, although in the latter case it is, of course, necessary to water the soil. In the lands inundated by streams, it is sown without previously manuring the soil, and in other lands manure is used, though in small quantities, and its effect is supposed to last four years. In a few places a kind of plant is used which lasts 10 years. It begins to yield a regular crop in the third year. No other things are sown with cotton. It is generally grown each consecutive year in the "Livadie," where during the winter the only plant that grows is the yellow clover. The ground is generally prepared for sowing at the end of March, which is done by thrice ploughing the land as deeply as practicable in furrows drawn at right angles to one another, and as closely as possible in order to break and pulverise the soil better. Three methods are adopted for sowing cotton; in each case, from the last week in April to the middle of June.

The first method.—This is used only for lands which are inundated, and consists in making deep furrows, 1 ft. 3 in. broad, by the double-board or winged plough. In order to obtain that breadth and depth, it is necessary to press heavily on the plough, and to pass it over and over again in the furrow. Six women generally follow the plough, and make holes in the centre of the furrow one foot apart. In each hole they place from ten to twelve grains of seed. The seed is very often prepared by steeping it in water mixed with sheep dung. The holes are afterwards filled up with the earth taken from them, and pressed lightly with the fist. When this is done, fine soil is scattered over for protection from the action of the sun. This manner of sowing cotton is called "sowing in furrows." After five or eight days the plants appear, and one month after they are thinned, leaving four or five of the healthiest plants in each hole, and the ground is weeded. This method is adopted when the overflow of water takes place, during the months of January and February.

Second method.—When the soil has been prepared, as in the first method, and inundated between April and May, seven or eight days are allowed to elapse to let the earth dry, and it is then ploughed with the usual plough; the women, as in the first method, follow the plough, making holes in the furrows, and putting the seed in each hole. When this has been done, they cover the seeds, without pressing the soil. Some farmers put seed in every furrow, others only in each alternate furrow. After the seed has been thus sown, the "Tavola" (harrow) is dragged over the ground to impress and level it. A month after, the plants are thinned, and the ground weeded as described in the first method. This second method is called "Pigliotica."

Third method.—The land which is not inundated, but only irrigated, is first manured, and then ploughed, in the usual manner, three or four times, at intervals of 10 or 15 days. The quantity of manure employed per scala cannot be positively stated, but it never exceeds 120 loads (20,160 lbs.) When ploughing and manureing are completed, a plot of land about 20 paces in width, from the whole length of the field, is watered, during which a man breaks the clumps of soil. The same operation is again gone through in the adjoining plot of ground. After seven or eight days, the "Tavola" is drawn over the soil, and a plot of land, 15 paces in width, is each time sown. The sowing is

done by scattering the seed with the land, or broadcast, allowing at most 30 oke, eqnal to 84 lbs. of seed, per scala. After this, the soil is once more plonghed, and the "Tavola" passed over it, on two successive days. After six or eight days the plant appears, and 10 days after the land is prepared for irrigation. The land is irrigated every 12 or 15 days. This method is called cultivation of cotton by the watering process; and the cotton obtained by this mode of cultivation has a longer fibre. If rain falls abnndantly before the plant springs np, its growth is retarded by the hardening of the soil; and in such case the soil is broken with the spades or with the "Tavola," furnished with rigid branches; an operation which is done under all the methods before mentioned of raising cotton. The cotton prodnced by the first and second method is called "Anedron," that is, not watered.

In all cases, when the cotton is ripe, which is generally about the 25th of September, asses and horses are allowed to graze in the fields, the opening of the pods being thereby accelerated; they take the leaves, without tonching the pods. At the end of September, or the beginning of October, the crop is gathered in, either by collecting the pods, or by picking the pappus from them. When the crop is got in, goats are allowed to graze in the fields. Cotton is picked by women, one woman being considered able to pick, in one day, 20 okes of pods. Cotton is then cleared of the seed by a gin, similar to onrs, worked by hand; bnt this system is rapidly dying ont in Cyprus, where steam-engines are being introduced.

The districts where cotton is most grown, are, first, the Messaorea, on the plains of Morpho and Nicosia; and, next, the districts of Larnaka, Buffo, Famagnsta, and Karpas. The better class of cotton, however, comes from the district of Lefka and Kythrea. In ordinary years Cyprns exports 3,000 bales of cotton, eqnal to 6,964 cwt., a very small quantity, indeed, in comparison to what might be produced in the island.

TELEPHONE EXCHANGES.

The last number of the *Telegraphic Journal* contains the following remarks on the systems of telephone exchanges described in the *Journal* of the 19th inst.:—

The remarkable progress of the speaking telephone in America has been nntil quite recently in very striking contrast with its apparent neglect in the United Kingdom. In America, the country of its birth, it has been eagerly adopted, and telephone exchanges are now established in almost every city of consequence throughont all the States. It is estimated that there are now more than 40,000 telephones in nse there. Chicago alone numbers over 2,000 subscribers to the far-speaking system which ramifies through that busy centre of trade, and the process of introdnction is rapidly being extended to minor towns, and even to remote settlements of the West. In the mining camps of Nevada and Colorado a telephone exhange is a sign of civilisation, almost as essential as a meeting-honse or a bar-room.

Nor are these exchanges confined to the precincts of each city; they actnally connect town to town, and thns enable the citizens of one town to converse with those of another, that is, if the distance between be not too great. Telephonic communication has, we understand, been sneeessfully maintained during the middle of the day, when the difficulties were at their height, between Philadelphia and New York—a feat which has also been paralleled in England.

On the other hand, althongh the admirable invention of Professor Bell was received in this country with loud acclaim, and gave rise to a mushroom crop of popular lectures and scientific experiments, it fell qnite flat upon the community in a practical sense. The original enthnsiasm soon passed away, and a pernicious faith gradually got abroad that the instrument was merely an interesting toy, very amusing to a drawing-room full of ladies, or highly ornamental to the physical cabinet of a philosophical *dilletanti*, bnt utterly unfitted for serions everyday use. That this belief was erroneous, is amply demonstrated by the extraordinary sneeess of the telephone in America. The characteristic slowness with which the English elect to throw off old habits and take on new ones, the prevalent dullness of trade, and, perhaps, a lack of enterprise on the part of those owning the appliance, have, also, had mnch to do with the telephonic standstill here. Our Post-office, unlike that of the German Empire, declined to take up the instrument, and Professor Bell was therefore cast npon his own resonrces. But he is understood to have been otherwise so hampered and retarded in his efforts to improve and introdnce the telephone in England, that he was glad to make his escape to America again, where he conld work with greater ease and more hope of practical sneeess.

The triumph of the telephone in that country has, however, at length infected England, and telephonic exchanges are now being established in London and other large towns. The Bell Telephone Company have turned their Coleman-street office into a central station for the City; more stations are likely to be opened soon in the metropolis, and other towns, notably Manchester, are arranging to have exchanges. The time appears to be ripe for them, and the City merchants are waking np to the advantages which they offer for expediting their bnsiness. Already a considerable number of snbscribers have come forward, and the system has got a flonrishing start. The terms charged by the Bell Telephone Company from each snbscriber are £20 yearly rental, everything being provided and maintained by the company. The Bell telephones employed as receivers are of the best American make, and a transmitter is used in order to give loud as well as distinct utterance. The exchange switch-board, call-bells, and other connections which have proved so efficient in America are also adopted by that company.

The discovery of the microphone by Professor Hnghes undonbtedly reduced the valne of Mr. Edison's carbon transmitter, which relied for its efficiency on the electro-magnetic telephone as a receiver, and that inventor, with characteristic plnck, thereupon set himself to perfect his electro-chemical receiver, and make it fit to take the place of the electro-magnetic receiver, which was at the best borrowed from Professor Bell or Mr. Elisha Gray. The English public have had many opportunities during the past winter of judging for themselves of his sneeess in this difficult task, and at last a telephonic exchange, on the Edisonian model, has been opened at No. 6, Lombard-street, and a number of subscribers gained.

Mr. Edison employs slender steel wires, electrotyped with copper, for his lines, so as to combine lightness, strength, and condnctivity. They are frrther covered with a slight coating of insnlating material, which insures their insulation and durability in the moist, corrosive atmosphere of London. The electro-chemical telephone is "loud speaking;" bnt, by a simple mechanical contrivance, it is provided that conversation can be carried on without being andible beyond the desired limit. A monthly rental is charged for the use of this system.

Now that the ice is broken, we anticipate that the telephone will be taken np with the cnstomary energy of our countrymen, and we hope soon to see the whole of London, as well as other large cities, divided np into districts, each frrnished with its central telephonic station.

Tasmania is said to be rapidly becoming a rival to Cornwall in the production of tin. In 1873 thirteen tons of tin ore only were exported, but, in 1877, the price of the exports of tin and tin ore nearly reached £270,000. The valne of the tin ore is increased by the presence of some gold,

PLATINUM IN THE UNITED STATES.

The *Scientific American* has the following note on the result of Mr. Edison's search for new sources of platinum:—

Notice was taken some time since of Mr. Edison's circular letter of inquiry with regard to the possible occurrence of platinum in various parts of the country. Mr. Edison informs us that, so far, he has received some three thousaud replies. Instead of being an extremely rare metal, as hitherto supposed, platinum proves to be widely distributed, and to occur in considerable abundance.

Before Mr. Edison took the matter in hand, platinum had been found in the United States, in but two or three places—in California and in North Carolina—and in these places it occurred but sparingly. It is now found in Idaho, Dakota, Washington Territory, Oregon, California, Colorado, Arizona, New Mexico, and also in British Columbia. It is found where gold occurs, and is a frequent residual of gold mining, especially placer mining. Mr. Edison thinks he can get over 3,000 lb. a year from Chinese miners in one locality One gravel heap is mentioned from which a million ounces of platinum are expected. Hitherto the product of the entire world would not suffice to supply electric lamps for New York city. Now Mr. Edison believes that our gold mines will supply more than will be required. The possible uses of this metal in the arts, however, are so numerous that there is no danger of an over-supply.

In addition to platinum, Mr. Edison finds, among the large number of samples received daily, many other valuable metals and minerals, so that his researches in this direction are likely to result in increasing greatly the resources of our country in respect to the rarer and more costly minerals and metals.

THE NEW FODDER TREE ("CALLIANDRA SAMAN.")

Taken in connection with an article which appeared in the *Journal* for May 30th, p. 604, vol. xxvii, on the new fodder-yielding tree (*Calliandra saman*), the following report from Lieut.-Colonel R. H. Beddome, Conservator of Forests, dated from the Pulney Hills, will be read with interest. He says:—"I procured small supplies of the seed of the *Calliandra saman* in 1869 and 1870, from the trees which had been introduced into Ceylon some years before, as I had heard that it was likely to be a most valuable fuel tree of very rapid growth. All this seed was sown in our Cuddapah fuel plantations; it germinated well, but all the trees have since died off, except two in the Kodur, and nine in the Pullampet plantations; of the former one is now 18 feet high, and 9 inches in girth, the latter are not healthy, and do not show good growth. The soil in these plantations are very poor, and the trees have taken their chance with others, and not received garden treatment. Again, in 1871, a small quantity of seeds were sown in the experimental plantation in North Arcot, near the foot of the hills, where the soil is good alluvial. Twelve seeds germinated; nine of which were sent to Palmanair, and planted in red gravelly soil, but are reported not to have grown well; the remaining three, which were kept where they were sown, have grown more rapidly than any other species of trees there, not excepting *Casuarina*; they are all about four feet in girth at three feet from the ground, and forty feet high, with wide spreading branches, one of which breaks off into three limbs near the base, each limb being over a foot in diameter. One of these limbs, cut towards the end of last year, contained upwards of a bandy load of timber. The forest officer in charge of the plantation reported that the wood was soft, and when used as fuel gives out a very unpleasant odour of ammonia. These three trees received what may be called garden cultivation."

There is a splendid example of the tree growing in the garden of the Judge's house at Tinnevelley, and there can be no doubt that the tree will answer admirably in good soil in the plains, particularly near the sea, if it receives garden cultivation, and it will be of value, Colonel Beddome thinks, for avenue and park purposes, as well as for the fodder yielded by its legumes, but it is not likely to be of value in the Indian firewood plantations and reserves, where anything like garden cultivation cannot be afforded. Colonel Beddome further gives it as his opinion that the tree is not "likely to succeed above ghauts, at least at any elevation."

CORRESPONDENCE.

COMMERCIAL EDUCATION.—GUILDHALL LIBRARY.

Besides their liberal contributions to Technical Education through the Society of Arts and other channels, the City authorities are bestowing some care on Commercial Education. The City of London College, which has received assistance from them, is likewise well known to the Society of Arts from its pupils taking many of our prizes. The Guildhall Library is doing good work in that way, which has not been fully appreciated.

The Guildhall Library is known as a liberal institution, with a good general library for literary students, and a free public library. Attached to the latter is, however, a department likewise under the care of Mr. W. H. Overall, the librarian, which is well calculated to do practical good. Some call it the Commercial Reference Library, and it has a convenient catalogue.

It contains, for instance, what is much wanted, a good supply of English, American, colonial and foreign directories, and the Corporation have taken great trouble to get some of these. There is also a good set of bank directories, very useful for reference as to the standing of firms. A set of reference books on commerce, the arts, agriculture, trade products, accompanies the collection, with many works on banking, currency, exchanges. A department of commercial law is well chosen, but it requires the French Codes, and the adaptations of them in Turkey, South America, &c., and some few other books on foreign commercial law. A body of newspaper and periodical publications supplies the latest detailed information, and the institution possesses a complete file of the *Times* and of the *London Gazette*. With what there is in the special library, and the further stores in the general library, the inquirer will find everything that is necessary to give the theoretical part of a commercial education freely at his disposal.

Beyond this, there is a portion which interests the Society of Arts, which has done so much for promoting the study of foreign languages for commercial purposes, including the special examinations in commercial correspondence, and in the speaking, for practical purposes, of German, French, Spanish, and Portuguese. This is a matter of particular importance to commercial interests, because, beyond all doubt, we suffer in competition abroad from the ignorance of foreign languages by our merchants, agents, clerks, and mechanics. Although there are so many teachers of school French and German, the want of provision for practical training in these and other important languages is seriously felt throughout the country. Notwithstanding our enormous trade with India, China, Japan, there is no such institute in London, Liverpool, or Glasgow, as a High School of Languages, with its teachers of Chinese, Japanese, Turkish, and other widely spoken languages.

It may be observed that the Guildhall Library affords aid in supplying another great want, the means for students to apply themselves to scientific studies in the higher branches of linguistics, as Egyptian, Assyrian, &c. Besides the dictionaries and grammars already in the library, I should recommend the Chairman of the Library Committee to make provision of modern dialogues, vocabularies, &c., so as to promote vernacular studies; as also to obtain for a Londoner, who may be so disposed, Testaments in the common languages. Many a clerk and young man out of employment, or in his leisure time, would thus be encouraged to acquire a knowledge of languages useful to him in his pursuits.

HYDE CLARKE.

32, St. George's-square, S.W.,
15th Sept., 1879.

GENERAL NOTES.

Primary Education in Paris.—From the last report on this subject we (*Times*) learn that new schools are being built to furnish accommodation for 4,834 children—viz., boys, 2,022; girls, 2,117; infants, 695. This will reduce to 18,861 the number for which it is necessary to provide accommodation in the schools, and to 5,805 that for the infant schools. A sum of 28,029,800 f. is to be devoted to building new schools and enlarging those already in existence, and the proportion for each class is as follows:—Boys, 9,265,000 f.; girls, 5,434,800 f.; infants, 13,330,000 f. To this amount must be added 3,600,000 f. for the upper division of the primary schools, making a total outlay of 31,629,800 f.

Crocodile Oil.—Mr. Purcell, of Agra, states that, if it were found of any commercial value, he could obtain a large quantity of crocodile oil. Dr. Kanny Loll Dey Bahadoor, Calcutta, states that, on examination, crocodile oil contains a larger proportion of solid fat than either the neat's foot, or cod liver and other fish oils. It solidifies at the melting point of ice, while neat's foot oil only slightly thickens, and the others scarcely thicken. He also tried the softening quality of the various animal oils on leather, and, on comparison, found the leather treated with crocodile oil remained much stiffer than that treated with other animal oils. Still, it may be worth testing by some manufacturers, if, in conjunction with the skins, the slaughter of these reptiles could be utilised.

Wine Produce in Europe.—The *Giornale di Agricoltura* gives the general results of a yet unpublished return on this subject, which has been officially prepared for the Italian Ministry of Agriculture. From this it appears that the average annual production of wine in the various countries is as follows:—France, 55,604,000 hectolitres; Italy, 31,500,000; Spain, 20,000,000; Portugal, 5,000,000; Austro-Hungary, 12,640,000; Germany, 6,501,000; Switzerland, 900,000; Russia and Turkey in Europe, 2,134,000; Greece, with Cyprus, 1,115,000; Roumania, 667,571. The total annual production of Europe is 146,121,646 hectolitres, or about 3,214,676,250 gallons. Since the invasion of the phylloxera in France, the average production of that country has fallen off by about 8,000,000 hectolitres a year.

Sanitary House Construction.—In view of the domestic dangers to health arising from imperfect workmanship by plumbers, and the use of improper so-called "sanitary appliances," the Council of the National Health Society announce that they propose to organise a series of lectures and demonstrations on elementary sanitary science to working plumbers. At the close of each series of lectures, money prizes will be awarded to those who gave the best evidence of having profited by the teaching. The National Health Society have reason to believe that, not only would the lectures be very numerously attended, but that the matter would become one of general discussion in the workshops; and they consider that such a movement can hardly fail to be of great public benefit. For further information, application should be made to the Secretary of the National Health Society, Berners-street, who will also be glad to receive subscriptions towards the cost of the lectures.

Prolongation of Patents.—A return to an order of House of Commons, has lately been issued, showing, in respect of each year, from 1870 to 1878 inclusive, the number of patents then in their fourteenth year, the number of applications to the Privy Council for prolongation, and number of prolongations actually granted. The number of patents in their fourteenth year varies from 221 to 178 in each year. The total number of applications for prolongations during the nine years was 49; the number of prolongations actually granted during the period 24.

The Sydney Exhibition.—The Colonial Office has been officially informed by the Governor of New South Wales of the opening of the Sydney Exhibition on the 17th of the present month. Other information comes to the effect that there is a very large display of agricultural implements already in order. The machinery in motion department is not yet completely ready, but the preparations are on a great scale, and there is every reason to believe that this department will be of much interest and practical use. The pottery and glass section is very good and extensive. There are 800 British industrial exhibitors and 613 fine art entries, including photographs. Germany has 695 entries, including 108 fine art; Austria, 170; France, 350 industrial and 168 fine art; Belgium, 236 industrial and 50 paintings. America has 150 industrial collections. Among the best-filled sections are railway apparatus and material, steel and cutlery from Sheffield, guns and miscellaneous manufactures from Birmingham, Manchester goods, sewing cottons, cloths, hats, india-rubber manufactures, chemicals, preserved foods, lamps and stoves, paper and stationery. The British Government collections comprise those of the Admiralty, Science and Art Department, and the School Board for London. The paintings include those lent by the Queen and Prince of Wales and by the Society of Arts. There are 175 British oil paintings, 111 water colours, and 97 architectural drawings. At a banquet held to celebrate the opening of the Exhibition the Queen's health was received with great enthusiasm, and warm acknowledgments were expressed for the appointment by her Majesty of the British Royal Commission for the Australian Exhibitions, an appointment which added considerably to the *prestige* of the undertakings.

Swiss Postal Service.—From a work on the Swiss roads and postal arrangements, by Councillor Bavier, the following facts may be collected. There are, it appears, in Switzerland, 13,353·5 kilom. of high roads (Hauptstrassen), a very large proportion in a mountainous country, the whole surface of which measures 41,389·8 square kilom. Of these 6,547·7 kilom. fall to so-called roads of the first-class, the cost of construction of which is put at 173,498,400 fr. Partly in this wealth of roads, and partly in the rapid extension of the Swiss railway system during the last few years, one of the chief causes of the uncertainty of the postal returns is to be sought, these having made the passenger post, which is organised on a highly liberal and expensive scale, a source of heavy loss instead of profit. In 1876 the Confederation owned 1,393 post carriages and 768 sledges, inventoried at a value of 1,733,310 fr. The total cost of this branch of the service in the year was 5,765,644 fr., and the net loss 2,276,148 fr. The number of passengers conveyed during the year was 1,329,303, of whom 278,884 travelled on what are distinguished as Alpine and Tourist routes. Of the great increase in Swiss travelling in the last 25 years some idea can be formed from the fact that the passengers forwarded by post in 1852 are given at 570,104, in which figures are not included travellers by rail. By a diminution of the number of services performed, and by a certain reduction in the salaries, which have largely increased of late years, the Federal Postal Department hopes to make the post-office yield a reasonable return. The figures for the last two years show already a marked improvement.

MEMBERS' SUBSCRIPTIONS.

Cheques or Post-office Orders for the above should be made payable to "H. T. Wood, or Order," and crossed "Coutts & Co."

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FRIDAY, OCTOBER 3, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

TECHNOLOGICAL EXAMINATIONS.

The City and Guilds of London Institute for the Advancement of Technical Education have issued their Programme for 1880 for the Technological Examinations which were transferred to them by the Society of Arts. The subjects in which it is announced that an Examination will be held are as follows, those marked with an asterisk (*) having been added this year for the first time :—

I. Alkali Manufacture.
II. Blowpipe Analysis (Practical).
III.*Brewing.
IV. Calico Bleaching, Dyeing, and Printing.
V. Carriage Building.
VI. Cloth Manufacture.
VII. Cotton Manufacture.
VIII.*Electro-Metallurgy.
IX. Gas Manufacture.
X. Glass Manufacture.
XI.*Goldsmiths' and Silversmiths' Work.
XII.*Iron Manufacture.
XIII.*Lace Manufacture.
XIV.*Manufacture of Oils, Colours, and Varnishes.
XV. Paper Manufacture.
XVI. Photography.
XVII. Pottery and Porcelain.
XVIII.*Printing.
XIX. Silk Manufacture.
XX. Silk Dyeing.
XXI. Steel Manufacture.
XXII.*Sugar Manufacture, &c.
XXIII.*Tanning Leather.
XXIV. Telegraphy.
XXV.*Watchmaking.
XXVI. Wool Dyeing.

It will be noticed that ten new subjects have been added, in addition to the sixteen included in the Society's programme of last year.

The Programme contains information as to the conditions under which the Examinations will be conducted, grants made to Teachers of Technological subjects, prizes awarded, &c. It also gives a syllabus for each subject, and examples of papers set in previous years.

Copies of the Programme can be had gratis on application to the Secretary, City and Guilds of London Institute, Mercers'-hall, E.C., or to the Secretary of the Society of Arts.

PARIS EXHIBITION.—ARTISAN REPORTS.

The selected reports on the Paris Exhibition, made by the artisans who were sent out last year by the Society of Arts, are now in course of publication by Messrs. Sampson Low and Co. The following have already appeared :—

1. { Pottery and Glass. Part I.
   { Pottery and Glass. Part II.
2. Art Workmanship.
3. Mechanical Engineering.
4. Agriculture and Horticulture.
5. Building Trades.
6. Cabinet Work.
7. Watch and Clock Making, Jewellery and Optical Instruments.

The remaining four parts are in the hands of the printer, and will be published in the course of a few days. They are—

8. Printing.
9. Textile Fabrics.
10. Leather and India-rubber.
11. Mining and Metallurgy.

The price of each part is sixpence. Twelve copies of any of the parts will be supplied at 4s. 6d. The complete series will also be published in one volume, price 7s. 6d. This also will be published immediately.

THE SUPPLY OF DRINKING WATER.*

At this present time, agriculture is seriously injured, and the sources of water supply are disturbed ,by extraordinary storms and floods. Our inquiries have been more extensive and closer than heretofore in the rural districts, and the conditious of the supplies are found to have intimate and extensive relations with the conditions of agriculture. The objects of agricultural science and art are to obviate the evils of excesses and deficiencies in water supplies. Their objects are not to make land dry, but moist—to adjust the moisture to the "hydroscopicity" of the soil, and to the proper feeding and growth of plants. And these conditions are conducive to the health of men aud animals, and to the purity of water sources, by avoiding the evils of stagnation, and also to the purity of the air, by the reduction of damp and the prevention of marsh miasma.

On traversing a district with an intelligent medical officer in the evening, we saw, from an elevation, a valley in great part covered with mists. "Those mists," said he, "cover the greater portion of my patients; outside, aud in the clear space, I have little demand for my services, except for midwifery cases and accidents." Damp reduces force, and generates rheumatism, and, when in excess, ague and fevers. Land surcharged with stagnant surface water, engendering the decomposition of animal and vegetable matter and marsh miasma, is, I need not say here, surcharged with water which it is dangerous to drink. Since the relief of our fen districts from surplus moisture, by open cuts or drains to so-called

* Extracted from the Presidential Address delivered by Mr. Edwin Chadwick, C.B., to the members of the Congrès de l'Eau Potable, which met last month at Amsterdam.

"sumps," whence it is carried away by steam power, the health of men and animals has been improved, and now scarcely ounces of bark are needed where pounds were formerly used as medicine. But the effluent water, discharged into the rivers, carries with it the surface washings of the land. Our improved mode of land drainage is collaterally a method of obtaining water of a superior quality. An inventive man, an old friend of mine, the late Mr. Smith, of Deanston, set to work to devise a reaping machine. But for his purpose a level surface was needed, so that his shears might make close and clean cuts. The ridges and furrows interfered with his operation. They carried away, by the surf washings of the soils, some of the most fertilising manure, and discharged it into the river, rendering the water of an inferior potable quality. He was led in pursuit of his invention to devise the method of removing surplus moisture through the land by permeable tile drains, instead of over the lands by open cuttings. By the depth of his drains he adjusted the water table to regulate the "hydroscopicity" of the soil. This was the origin and principle of the system of subsoil drainage by permeable drains, now in extensive use and progress iu England, though, from obstacles too long to detail, in far smaller proportion than the needs.

You may observe in passing through the lower districts of Holland, Belgium, and France, the stagnant water of ditches standing within some foot of the surface, and that, although the tillage may be good, that the crops are thin. "Through" drainage, by lowering the water table to the depth required, which may be some three feet below the surface, gives the plants a proportionate augmentation of feeding ground, with the result of a larger yield of produce.

In some instances this work has repaid its expense iu four years, and generally it has repaid itself in eight years. In Holland, you have at the farm of Mr. Amersfoort, Lake of Harlem, a normal example of the working of this system of "through" drainage, with the economic results of a considerable improvement in the health of cattle, and, I am confidently assured, with a corresponding result of the improvement of the health of the labourers employed, as compared with undrained lands. You will see from these facts that landed interests are deeply involved iu the sanitary aspect of this question, by promoting the health of the workmen and of the stock upon their farms.

By this process of "through" drainage, the manurial surface matter, which was washed from the land into the streams, rendering them of inferior potability, is carried down into Nature's laboratory, and enters into chemical combination with the soil, being absorbed by the roots of the plants. For our purpose of water supply the soil is, by this process, constituted iuto a natural filter. Artificial filters are of narrow capacity, aud even those of the best construction soon become clogged, but filtration by permeable drains—each of which may be considered a long filter, it may be fifty or a hundred yards long—through soils occupied by vegetation, where the surface water is not intensely charged with manurial matter, is more effectual than any other, and even where the water is surcharged with manurial matter, as in the sewage farms, the effluent water is found to be more purified than by any other method of filtratiou. Ou observing the outfall of surface and subsoil drained land, you see the contrast—from surface drained land the outfall after storms is running like thick soup; the outfall from the subsoil drained land, when the work is properly done, will be seen running in a clear crystalline stream, of inviting appearance and real potability. Where sandy land is uncultivated and unmaured, the water discharged is purer than rain water, because, in passing through the sand, the sparse vegetation deprives the water of the washings of the air through which the rain has passed.

In our first General Board of Health we engaged Mr. Smith, of Deanston, the first inventor of the subsoil system, chiefly for the purpose of directing its application for obtaining potable water for the population, in cases where there was adjacent uncultivated sandy land, available for the purpose. But we lost his services by death, before he could apply them. In the first instances where the principle of subsoil drainage was applied, we found the areas required for supplies were more extensive, and the storage needed was greater than was at first estimated, and more powerful obstacles from the landed proprietors to the removal of the surplus water, by which they would have been greatly benefited, had to be encountered than was to be expected. But where the works were properly conducted, supplies of potable waters were obtained, well aërated and of a superior order, and such as would often make the fortune of a watering place as a health resort. This branch of our subject is of an amount of importance that would alone well occupy the labours of a distinct association for its advancement.

We have also natural subsoil filtration as a means of obtaining pure water free from animal or vegetable organisms. The deeper the filtration through natural strata, such as those of the chalk formation, the more perfect the precipitation. But then the deeper those sources are, the greater usually are the mineral impregnations drained in the course of the water. Now, every grain of chalk in water reduces its solvent power for food, as well for other purposes. We have had evidence that persons accustomed to soft water become dyspeptic when removiug to hard water districts. Animals, horses particularly, are frequently much affected by the change. But by the process called "Clark's process," of adding lime to precipitate dissolved chalk, it is possible in many cases to reduce the amount in solution from sixteen or eighteen grains per gallon, or degrees of hardness, as it is called, to between four and six degrees of hardness. The process has been carried on in some very successful instances, on a sufficiently large scale to prove its extensive applicability. Mr. Bateman, the well-known English engineer, who has conducted some extensive works for bringing in soft water chiefly from the surface washings of granite or strata of the primitive formations, observed to me, that in one instance where he had applied this "Clarke's process," he considered the water obtained to be about as good as his Loch Katrine water, a water of some two degrees of hardness, but I venture to believe that water so softened is better than the Loch Latrine water, delivered with its "water lice," generated in the uncovered reservoir lake, or than water derived from the surface washings of granite, in times of storm containing infusions of peat, which do not agree with the dyspeptic.

Let me now state how in these times the supplies of potable water, chiefly for urban populations, are commonly affected by the widely prevalent methods of collection and distribution. The old supplies from wells, with the addition of the rain water collected from the roofs of buildings, having been found to be insufficient or inconvenient, and deteriorated by the soot from the roofs, aud the local authority being incompetent to judge of new works, or unwilling to incur the respousibility of undertaking the supplies as a public service, some engineer, or contractor, or a solicitor, has invited capital for the formation of a company, to undertake the work as a speculation for a trading profit on a guarantee of a monopoly, and a trading promise of a high dividend. Recourse is had, most frequently to the nearest river, as the source of supply obtainable with the least trouble, and without contest with proprietors, by going far afield for spring sources—but without much regard to the importance of purity in the quality of the water. The quality of the river supplies may not be much affected by the surface washings of the lands, except

when they are highly manured, or washed by considerable storms. But they are affected injuriously to an increasing amount by the sewage of towns, by all the fouled water from kitchens and domestic uses, even where the towns and villages are not water-closeted. It is important to observe, as found by our commissioners of inquiry into the purity of river waters, that the water-closet system adds only about one-fifth to the common pollutions of river waters. We found these river waters carried for storage, and for the subsidence of impurities, into open reservoirs. There vegetation and animalcules rapidly appear, and rapidly die, and taint these waters with their putrefaction.

Filter beds are sometimes added to take out much of that which the open storage reservoirs have generated or taken in. But the microscope demonstrates that filters generally are only sieves which arrest large visible living organisms, and often let pass invisible animal organisms, and the most deleterious matters for potable water. Such have been, and frequently are now, the conditions of the large external works of public water supply. The supplies so collected are delivered into the towns intermittingly, mostly at intervals of days, when the water is subjected to the most dangerous conditions of all for potability. The highly absorptive power of water, and its avidity for some gases to many times its own bulk, is generally overlooked. In conditions of stagnant detention in butts and cisterns it absorbs the noxious gases of cesspools and all decomposing refuse.

It has recently been demonstrated that water of the highest purity—deep chalk spring water—free from all living organisms, and highly aërated as conveyed in mains, is de-aërated under conditions of stagnant detention; when, imbibing the impure air from drains and cesspools, it becomes more dangerous to drink than even inferior water derived from river sources, which is taken direct from the mains without detention in cisterns, especially in ill-drained and ill-cleansed neighbourhoods.

The knowledge of the carrying power of water for the transmission of specific disease has lately been greatly extended, that is to say, as to its power of transmitting the excrements from patients labouring under specific disease, and the epithelia diffused in close rooms, from patients suffering from scarlet fever or small-pox. Water, polluted with the emanations from diphtherial patients, has been given to kittens and chickens, experimentally, and produced diphtheria in them. The effective analysis of water comprises the analysis of the air which it absorbs, and, although air-analysis has been greatly advanced by Dr. Angus Smith and other chemists, there is confessedly much yet to be done in it. But it may be said that in drinking water from a mountain source, which has been taken direct, and without exposure and stagnation, we are drinking mountain air; taken after stagnant detention in open cisterns in towns, we are drinking town air; taken after the stagnant detention in the crowded, ill-ventilated sick rooms, we may be said to be drinking the seeds of the prevalent diseases of the zymotic class. Medical officers of health have declared to us that, in towns so supplied, they are very chary of drinking water unless they know its source, and that they prefer alcoholic drinks. The general security is, that water is not habitually drunk in districts so supplied, except by accident or necessity. It is only used as tea, or as soups, after boiling, when the dangerous elements are eliminated or reduced. The general fact with us in London is, that the mass of the wage-classes do not drink water but beer, or some alcoholic beverage, hence the gigantic evil of intemperance and unthrift from which we suffer, to contend against which is one of the great objects of our movement for obtaining potable water for the population. What is to be said of the state of those who use death-rates of populations as tests of the qualities of water which they never really habitually drink!

One evident evil of the common methods of supply by companies, for a trading profit is, that they usually have no effectual control or interest in exercising any supervision over the distributory apparatus, or the care of the closets, or the prevention of waste. The consequence is that the waste is immense. In London it amounts to three-fifths of the water distributed. In London the quantity distributed on the intermittent system of supply is thirty-two gallons per head of the population. At Amsterdam the supply is only ten gallons per head, large public consumers included. It is true only a small part of the city is water-closeted, but if all the houses were so treated it should only add one gallon per head to the existing consumption. There is this result from the waste of water in London, that the surplus fouled water permeates through bad house-drains and permeable sewers, and super-saturates the subsoils and creates marshy sites. In instances where the supplies have been placed with the whole of the distributory apparatus on a public footing, and the waste effectually reduced, there has been attendant upon the reduction of the damp in houses, as at Liverpool, a marked reduction of the sickness and death rates. It has been stated to me that in one town on the continent, the wells having become excessively polluted, recourse was had to a pipe-water supply; but, as no measures had been taken for the removal of the water and the prevention of waste, and the drawing from the wells—which previously had lowered the water-level beneath the sites—having ceased, the water-level rose, and so, with the waste of the new pipe-water supplies, the site was made a swamp, and the whole town was put in a worse sanitary condition than before. The effect of the better potable water was counteracted by the excess of damp from the fouled water. On such and other experiences, it results, as a sanitary axiom, that the duty of carrying fouled water out of houses, and out of towns, clear of the sites, constantly through self-cleansing channels, shall, with the duty of carrying water into houses, devolve upon one and the same authority, and that authority shall be a competent and responsible public one. We have numerous satisfactory instances, chiefly in small towns, of the working of this principle of sanitary administration, where the service of taking out the water, as well as of taking it on to the land, has been extended to the application of the sewage to agricultural production, so that there is no stagnation either of the fresh water, or the fouled water, or the sewage applied to the land. Nature abhors stagnation! Our first great object of getting potable water for villages and towns for the sake of health and temperance, is indeed combined with the means of getting well collected and well distributed water for the great sanitary objects—clean persons, clean habitations, and clean air.

In the absence of the light of science and administration, we have lately found too many towns in no better condition than that in which they were many years ago. The houses, and the streets, and the people filthy, the air fœtid, typhus and other epidemics rife, all mainly arising from the presence of filth, which is defined as "matter in its wrong place;" the immediate and complete removal of which to the right place—the soil—would in a great measure avert the recurrence of disease, restore health, promote abundance, cheapen food, and increase the demand for beneficial labour. Outside the depressed urban districts, at a short distance from them, in adjacent rural districts, we still find the aspect of the country poor and thinly clad with vegetation, except with rushes and plants, favoured with a superabundance of moisture, the crops meagre, the labouring population afflicted with rheumatism and other maladies arising from damp, due to an excess of water, which if removed to its right place, the town, would relieve the rural population from a cause of disease and an impediment to production. The town population would receive in return the element of which

they are most in need for the sake of health, and which, returned to the land, would be a means of the highest fertility.

We have now got increasing instances where this venous and arterial system has been brought into more or less effective action, and with advancing science it will be achieved completely. Not long ago I took an inspector, sent by the King of the Belgians, to examine some of these instances. In Croydon, for example, the whole of the sewage of sixteen thousand houses was being constantly removed without any stagnation, and was on the land, not in mechanical suspension, but in chemical combination with the soil before the middle of the day, with the result of four or five-fold crops beyond the ordinary culture, and with the further result that the death-rate within the town was reduced by more than one-third of what it was in its previous insanitary condition. The like is to be found in the town of Bedford. We have now instances of the application of the principle to villages where the water, carried in pure, is carried out direct when fouled, and immediately applied to the land, not by surface, but by subterranean irrigation. In the instances of the towns, any remaining offensive smells indicate the presence of causes of preventable insalubrity, at the same time that it proves defective workmanship, and bad local administration. You may test the local intelligence and administration by the nose. On the other hand, outside the town, and on the land, any stagnant sewage on the surface, and any offensive smells from super-saturation, indicate the preventable loss of fertilising matter and bad husbandry. With the progress of sanitary art and science, this will be remedied, and the principle of De Candolle, the great vegetable physiologist, that the future of agriculture will be in giving food and water at the same time, will be realised. I am happy to state that the German engineers have studied the principles elaborated under our first General Board of Health, have adopted them, and are applying them. At Berlin they have taken the water out of the hands of a private company, and are extending the delivery of it direct into the houses without cisterns. They are endeavouring to dispense with the river sources by spring sources derived from the drainage of adjacent sands. They are water-closeting the houses, and conveying the fouled water by self-cleansing drains and sewers, not to the river, but to the land, where, from such portions as have already been thus fertilised, they have got such crops as were never before yielded by German soil. If these works are completed on principle, I anticipate that the seat of the great German Empire, which has heretofore been a seat of the most foul stinks and pestilence, will be cleansed and purified, to become the healthiest of any capital in Europe.

I might adduce instances of sanitation by water-power in institutions under public control. The best tests of all are children's institutions, where, by the use of that power to obtain air-cleanliness by self-cleansing drains and water-carriage, the sickness and death-rates have been reduced by one-third; and by personal head-to-foot ablutions, combined, no doubt, with the dietetic efforts of fresh, pure, and potable water, the death-rates have been reduced by another third—effecting by both factors a reduction of the sickness and death-rate to one-third of those prevalent amongst the general population of the same ages.

We put forth drinkable water as our foremost object, but that, I need not state here, involves washable water for the person and for clothes, and solvent water for culinary purposes, and for manufacturing purposes, and also suitable water for steam power, without the incrustation of boilers. As my apology for thus particularising, I may state that, in the course of my service as the chief executive officer of the first General Board of Health in England, I had to examine the supply of water in our metropolis, and in a number of our provincial and manufacturing towns, and had to propound sanitary and administrative principles, which are now recognised, and in course of extended practical application.

I will conclude, gentlemen, with a summary statement of the general conclusions to which sanitary science has, I consider, arrived at in England, for the extension of improved supplies of potable water. The first is, for the improvement of machinery and methods of distribution, by connecting the house service pipes with the street mains as parts of one system, and that a public one, responsible for the removal of all conditions of stagnation, as in cisterns, by which the best supplies are made bad, and bad supplies are made worse. The next is a condition insuring that the service of carrying in pure potable water, shall be united with the duty of immediately carrying away fouled water, and preventing stagnation by removal through self-cleansing drains and sewers, and applying it direct to the land. The third conclusion regards the sources of supply, abandoning as soon as possible river sources containing, besides the sewage of towns, the surface washing of lands, especially highly manured lands, and substituting by preference supplies from spring sources, or sources derived from primitive rocks or clean surfaces; and, where good natural springs are not within reach, creating artificial ones.

Gentlemen, such are the conclusions, and such the outlines of experiences in England, reduced from early and wide observation during my official service as the chief executive officer of our first General Board of Health, and set forth in voluminous documents. We shall invite your information derived from observation, in your separate fields of service in your respective States, that we may combine them, to direct their collective force to the relief and advancement of our populations.

If I may be permitted to offer one suggestion, it would be that on the controversies as to the eligible qualities of water, I may say that observations of the effects of different sorts of water upon individuals are perplexed by idiosyncrasies. But we may clearly see the results on classes of people under similar conditions. Thus, in a prison supplied with the sewer-tainted water of the River Thames, cases of typhoid fever were frequent. The sources of supply were changed to spring sources, and fever almost entirely disappeared, and there was a marked advance in the general health. In one prison there was an outbreak of diarrhœa, such as prevailed regularly amongst the outside population. Accidental contamination of the water in the prison cistern with sewage gas was detected. When that was prevented, health was restored. In one prison, cases of goitre appeared. They were suspected to be due to the water. The water was changed, and cases of goitre ceased. The most important collective test as to the value of pure water supplies are those on board our steamships of war. All are now supplied with soft water distilled from sea water and duly aërated. The men in our ships of war on the Chinese station were most severely attacked with dysentery. The cause was detected to be their carelessly drinking, when on shore, the water used by the people. The men were strictly ordered to drink no other than the distilled soft water on board. This was done; the dysentery ceased, and health restored. As compared with the supplies obtained from the common sources of potable water got from shore, it is considered greatly superior, and is a great sanitary boon to our Navy. There is no doubt that the superior quality of the water thus supplied to the Royal Navy is one of the chief factors contributory to the greater healthiness of the sailors of the Royal Navy over those employed in the mercantile marine.

Nicety in the supplies of potable water for urban and sedentary populations is of more importance than for rural populations, as the urban populations comprise a larger proportion of sick and weakly subjects. I have

had no time, nor is it necessary that I should advert to the obstructions to sanitary improvement, by defective legislation and administration. I may state that more favourable anspices are dawning upon us, and that those obstructions are in course of reduction and removal. I beg to repeat in the hearing of the scientists, by whose presence we are honoured, the dictum of an early ally, the late Dr. Wilson, of Truro, which I cited in my report on the sanitary condition of the labouring population of Great Britain. After having related some particular improvements which had taken place as it were by chance, and independently of any particular aids of science, Dr. Wilson observed that "it is impossible to avoid the conclusion, that much more might still be accomplished, could we be induced to profit by a gradually extending knowledge, so as to found upon it a more wisely directed practice. When man shall be brought to acknowledge (as truth must finally constrain him to acknowledge) that it is by his own hand, through the neglect of a few obvious rules, that the seeds of disease are most lavishly sown within his frame; when he shall have required of medical science to occupy itself with the prevention of maladies rather than with their cure; when Governments shall be induced to consider the preservation of a nation's health an object as important as the promotion of its commerce, or the maintenance of its conquests; we may then hope to see the approach of those times when, after a life spent almost without sickness, he shall close the term of an unharassed existence by a peaceful euthanasia."

Since this dictum was cited we have made important advances; we have obtained examples of the reductions of old death-rates by one-third, and even one-half; and we have established correct normas and some sound factors of sanitary science; and we now await amended legislation. We have gained from the present Prime Minister of England the repeated declaration, which we are assured is in accordance with the deepest sentiments of her Majesty, that the study of the health of the population is the first duty of a statesman. Now that we have some relief from foreign complications, our metropolis is in a position of expectancy and hope, as to the measures of improvement in the water supply of London, which such study of available experiences may under our popular Minister of the Home Department, Mr. Cross, direct.

HUGHES' INDUCTION BALANCE.

Mr. W. Chandler Roberts, F.R.S., Chemist of the Mint, read a paper before the Chemical Section of the British Association at the Sheffield meeting, "On Some Experiment with the Induction Balance." He stated that the instrument appeared to be one of no ordinary importance, and although the experiments he had made were far from complete, they possessed sufficient interest to justify their being submitted to the Section.

The relative values of different metals, as indicated by the induction balance, do not accord with the values usually accepted as representing the relative conductivities of the respective metals, and this being the case, Mr. Roberts had ascertained what relation the indications given by alloys, when under the influence of the induced current, bear to their electric conductivities.

The experiments on a comprehensive series of alloys proved that, in the case of alloys of certain metals, the induced-current curves closely resembled those representing electric conductivity, but that in certain other cases the induced current revealed differences that had hitherto escaped observation. As an example, Mr. Roberts alluded to the curve of the copper-tin alloys, in which there is a sudden break between the points representing two alloys, which only vary by a single equivalent, or by 6·4 per cent. of copper. These two alloys are widely different in colour, fracture, density, and structure, and the induction-balance at once afforded evidence of a marked difference not shown in Matthiessen's curve of electric conductivity.

It is known that certain metals, when alloyed, undergo a molecular change, and that an allotropic condition may in some cases be induced by alloying a metal with a small quantity of another, facts which well deserve minute examination as bearing on the non-elementary character of certain metals, which is now receiving so much attention.

Mr. Roberts then referred to the question of applying the induction-balance to the assay of metals. In the case of gold-silver alloys, the instrument will show the presence of less than two grains of gold in the pound of silver. On the other hand, the silver-copper alloys used for coinage are situated at the flat portion of the curve, so that it is impossible to detect even considerable differences in their composition, and these alloys, which are very peculiar to their nature, appear to be greatly affected by annealing. More hopeful results were obtained with the gold-copper alloys, and Mr. Roberts demonstrated a difference of 1 per cent. in the standard of two gold disks, which, though far short of the existing method of assay in delicacy, appeared to afford grounds for the belief that very accurate results will ultimately be obtained.

PRODUCTS OF THE VOLTAIC ARC.

Shortly before his death, the late Mr. T. Wills, of Greenwich Naval College, made the important discovery that nitric oxide is formed in the voltaic arc. More recently Professor James Dewar, F.R.S., of the Royal Institution, has determined the curious fact that hydrocyanic, or prussic acid, that deadly poison usually distilled from laurel leaves or bitter almonds, is formed in small quantities in the voltaic arc.

A series of experiments favouring the conclusion that the so-called carbon lines are invariably associated with the formation of acetylene (as suggested by Plücker, Angström, and Thalén), induced Professor Dewar to make some experiments to ascertain whether this substance can be extracted from the electric arc, which invariably shows this peculiar spectrum at the positive pole, when it is powerful and occasionally intermittent. For this purpose the carbons were used in the form of tubes, so that a current of air could be drawn by means of an aspirator through either pole, and the products thus extracted from the arc, collected in water, alkalies, and other absorbents. Gases may be led through one of the poles, and suction induced through the other, in order to examine their effects on the arc. The experiments were made by means of Siemens' and De Meritens' magneto machines. Hydrogen led in by the positive pole, and the gases extracted, gave the well-known acetylene compound with ammoniacal sub-chloride of copper; while, at the same time, a wash-bottle containing water gave distinct evidences of the presence of hydrocyanic acid. Air drawn through the negative carbon gave considerable quantities of hydrocyanic acid, which was greatly increased by extracting the gases through the positive carbon. Carbons purified in chlorine and hydrogen gave, with De Meritens' nothing; with Siemens', and a draught of air through the negative pole, a small quantity of hydrocyanic acid, but a larger yield when positive was used. The gases extracted after the absorption of the hydrocyanic acid contained acetylene. If the carbons are not purified, sulphuretted hydrogen is always found along with other gases. The inference to be drawn from these experiments is that the high temperature of the positive pole is required to produce the reaction, which is, in all probability, the result of acetylene reacting with free nitrogen, as when induction sparks are passed through the mixed gases, viz.:—$C_2 H_2 + N_2 = 2 H C N$, and that the hydrogen is obtained from the decomposition of

aqueous vapour and the combined hydrogen in the carbons. It is possible traces of alkaline salts in the carbon poles may favour the formation of hydrocyanic acid, but, as all attempts to purify the poles so as to stop the reaction failed, it appeared to be a direct synthesis. The acetylene reaction is one of the many remarkable syntheses discovered by Professor Berthelot, of Paris. The presence of sulphuretted hydrogen is doubtless due to the reduction of the sulphates, invariably present in the ash of the carbon. A more complete examination of the various reactions to be brought about by means of the Siemens' arc, and with poles of varied composition, and in presence of different gases, has also been made by Prof. Dewar, and is promised for future publication.

The hard diamond-like deposit of carbon, which after a short time is found to obscure the interior of the globe of an incandescent carbon electric lamp, like the Sawyer-Mann, has also been made the subject of analysis by Mr. B. S. Proctor. The lamp examined was made by J. W. Sivan, and exhibited to the Newcastle Chemical Society in December last year. It consisted of a glass flask, which after being filled with nitrogen was exhausted by a Sprengel, and an incandescent pencil of carbon. It was, therefore, supposed to contain nothing which could carry carbon from the glowing pencil to the cooler surface of the glass around it. Platinum contacts were employed to connect the current with the carbon.

Under the microscope the smoky deposit on the glass showed numerous bright globules, no doubt of platinum, and more minute particles of dark matter, nebulous, under a $\frac{1}{4}$-inch objective. On exposing the glass to an oxidising heat, the deposit partially disappeared, still leaving the glass partially darkened however.

The platinum support was coated with dark sublimate. The deposit on the glass was not entirely dissolved by *aqua-regia*, and analysis showed that the soot contained platinum, carbon, and iron. The platinum globules might result from the disruptive discharge which took place at the moment the lamp failed.—*The Telegraphic Journal.*

BIBLIOGRAPHY IN FRANCE.

The important subject of bibliography is attracting attention in France as it is now in England. The Minister of Public Instruction has announced that an examination will take place in the present month of October, at the Library of the Arsenal, of candidates for certificates of aptitude for employment as librarians at the Universities and other public establishments. Registers are open at several acadamies for the inscription of names of candidates. Besides the certificate of his birth, such candidate is required to state what his former occupations and studies have been. The examination consists of two written proofs:—1. A composition in French on a question relating to bibliography. 2. The classification of fifteen works treating of different subjects, and belonging to different epochs of printing.

According to a general instruction issued last year, the latter trial must include numbering, and entries in library reception book, and alphabetical and classified catalogue. Close and perfectly clear handwriting is an indispensable condition. Four or more appointments of librarians will be made after the examination.

This is undoubtedly a first step in the right direction. It is curious, however, to note that our neighbours continue to cling to the idea of classified catalogues, which has long since been given up by the great majority of librarians and others who take any interest in bibliographical arrangements. Readers have not yet the benefit of an alphabetical catalogue at the Bibliothèque Nationale of Paris, only classified catalogues of a few subjects.

CATALOGUE OF PRINTED BOOKS.

At the recent meeting of the Library Association at Manchester,

Mr. Thomas read the further report of the committee on a general catalogue of English literature. The report stated that in April, 1879, the Council of the Society of Arts published their report, addressed to his Royal Highness the Prince of Wales, on "The Universal Catalogue of Printed Books." In the report they issued they recommended "that, before the inquiry into the cost of printing the Universal Catalogue is carried further, it should be ascertained if the Government would entertain the idea of printing the catalogue of the printed books in the British Museum down to the end of the year 1878, in the cheapest practicable form, suitable for use in all the public libraries at home, in our colonies, and abroad." They were asked by their president, the Prince of Wales, to consider what would be "the cost of producing a universal catalogue of all books printed in the United Kingdom previous to year 1600." The inquiry turned into a discussion upon a general catalogue of all English literature, and the Council had concluded by recommending the printing of the catalogue of the books in all languages contained in the British Museum. A circular issued by Mr. Bond in August last announced that the trustees of the British Museum have had under consideration a proposal to print in future the accessions to the general catalogue of the British Museum, and to publish them at short intervals, and it invites subscriptions for copies of these entries. The titles, it was said, would amount to about 60,000 annually, and it would be printed without any arrangement, alphabetical or otherwise, on one side of a leaf, with a view to being laid down in slip-catalogues. Though the lack of any arrangement must prove a serious hindrance to the usefulness of such a list for other libraries, and for purposes of general consultation, this proposal must be hailed as a sign of progress, since it would probably involve, sooner or later, the printing of the Museum's earlier titles, and it might be hoped in such a way as to be of the utmost possible advantage to the literary public. The scheme had an obvious bearing, therefore, not only upon the proposal to print the Museum catalogue, but also upon the general catalogue of English literature. The committee were in favour of the latter rather than the former of these two proposals. It seemed to them that the printing of the Museum catalogue as it stood was quite inadequate to our needs as regards English literature, and that if the titles of the English books in such a catalogue were to be reprinted in a subsequent catalogue of English literature, an immense cost and trouble would be incurred twice over. As before, the committee felt that the true solution of the whole matter lies in the co-operation of our great national library with the other more important libraries throughout the country. If other libraries would supply the Museum with the titles of English books which the Museum does not possess, and the Museum would consent to incorporate them into the catalogue of their own English books, the task would be achieved.

In the course of the discussion which followed, **Mr. Garnett**, superintendent of the reading-room, British Museum, said they were beginning to find at the Museum that the present system of making entries in manuscript was bad. They were continually increasing the size of the catalogue, and before long it would be necessary to print the entries, if for no other reason than to reduce their bulk. He might state that he believed Mr. Bond, the principal librarian, had under consideration the question of at once adopting print.

Mr. Harrison (London) saw in the proposal named by the last speaker the beginning of a universal catalogue of English literature.

Mr. P. Cowell (Liverpool) thought the reception of

60,000 entries a year would be very like receiving a "white elephant." The Liverpool Library would no doubt be prepared to subscribe, but it was a serious question as to what they would do with the number of entries and titles they would receive.

Mr. Garnett said the catalogue might be printed in classes, so that libraries would not be compelled to subscribe for the whole of the titles unless they desired.

POPULATION AND INDUSTRIES OF SUEZ.

Consul West, in his report upon the capabilities of Suez, states that, as an outlet for British manufactured goods, whether in the shape of hardware or textile fabrics, there can be little doubt that the entire coast of the Red Sea is an almost unexplored region; the people are undoubtedly poor, but the products of the poorest of the inland districts are valuable—and some of them are very valuable—when they are brought to the coast. This is in itself an element of trade, and the facility with which, as a rule, such goods as those above named —which, in point of fact, are the first requirements of a semi-civilised or uncivilised population—are bartered for the rough produce of the countries they inhabit is sufficient to induce a belief that our trade with the coast of the Red Sea is susceptible of a fair amount of development. Quarantine restrictions are undoubtedly a serious check to all fair trading operations, not only on account of the loss of time and heavy expense they cause, but owing to the utter disorganisation they create in any regular line of steam navigation, and to the uncertainty which must always be one of the hardships inherent to their enforcement, while, in the present state of our Red Sea trade, carried on, as it is in a great measure by steamers calling at Jedda on their way to and from far distant ports and places, they paralyse all tendency to regular development and uninterrupted communication.

The pilgrim traffic during the past season was very limited, not more than 10,000 pilgrims having passed by way of Suez; the nationalities represented were Egyptians, Turks, Moors, Algerian French subjects, Syrians, and Javanese from the Dutch settlements. The number of native resident inhabitants has lately been somewhat reduced, owing to the laying up of several of the Khedivieh postal steamers, and to the removal of others. The Greeks are the only people who (other than natives) seem to earn an independent livelihood at Suez; it is true they are frugal and painstaking, and it is equally clear that, industrially and commercially, they manage to live and thrive. The articles they mostly deal in are haberdashery, hosiery, ready made clothes, groceries, oilman's stores, and imported edible produce of all descriptions, including fruit from Port Said, tobaccos, cigars, and cigarette paper, pipes, &c. A not inconsiderable quantity of common wine from the South of France is brought to Suez by the French Messageries steamers, and finds a ready sale. The agriculture in the neighbourhood is still very limited, cultivation barely producing a supply of vegetables equal to the demand in the town; the land is chiefly made to produce Egyptian clover, the growth of which improves the soil, and the clover itself, whether fresh or dried, finds a ready sale; the single cutting of an acre of green clover being paid for at the rate of 4s. to 5s., while a field, if properly watered, will produce five or even more crops in the season.

The present financial state of Egypt is sufficient to account for the total abstention from all attempts at improvement in the form of public works. Too much money has already been injudiciously spent by the Egyptian Government at or near Suez, to induce any further attempt in that direction, even if the means required to make it were forthcoming—which it is to be hoped they are not—unless, indeed, they are to be laid out with greater discernment and less disregard for the requirements of the place itself. There was a considerable falling off in the amount of traffic through the canal in the year 1878, as compared with that of the preceding year, 1877; and had it not been for the movement of troops, to and from India, the loss of traffic would have been still more severely felt. The importance of Suez to British interests, Consul West thinks, must be permanent, and will in all probability be increasing. Suez is the link that holds the independence of our communications with the far East; it is even doubtful if the route by the Euphrates Valley were rendered available, whether "viâ Suez" would not still be the quickest, as it would certainly be the safest, route to Bombay.

PETROLEUM AS FUEL.

A method of using petroleum as fuel for steam boilers has been recently tried at Pittsburg (U.S.) with, it is said, complete success; and, as oil can be had anywhere in the region of the wells for about 70c. a barrel, the company who hold the patent believe that the invention will be readily taken up, especially by the owners of steamboats. It resembles, according to the Journal of the Franklin Institute, in its principal features, many of the forms previously described—air, steam, and oil-spray being injected into a suitable fire-box. The spray is said to be immediately converted into inflammable gas, becoming a pure, bright, powerful flame, devoid of smoke and producing intense heat. To accomplish this result extremely simple machinery is used. A small hole is drilled into the iron front of the fire-box, and into this passes a tube, which branches as it leaves this point into two pipes. One of these connects with the boiler itself, and the other with the receptacle containing crude oil. At the junction of these pipes there is an aperture for the admission of atmospheric air. Valves of peculiar construction regulate the quantity of steam or oil admitted into the furnace. This is all the machinery required, but its operation, according to the *Pittsburg Telegraph*, is wonderfully complete and remarkably successful. The little steamer *Billy Collins* was selected for the test, and was fired up at 9 a.m. A preliminary blaze of wood under the boiler raised the small quantity of steam necessary to start the burner into operation. The oil valve was opened a trifle, the steam valve ditto. The petroleum trickled into the feed pipe, was caught up by the steam, and both plunged into the depth of the fire-box, a mass of many-tongued, roaring, brilliant flames. As the pressure of steam increased, this flame grew in fury and intense heat, roaring through the entire length of the boiler with a sound like the coming of a thunder-storm. The needle of the steam-gauge climbed rapidly up the dial, and in twenty minutes the safety-valve blew off at 120 lb. pressure. Here was a boat puffing through the water with no sign of smoke from her chimney, no speck of soot in flue or fire-box, no fireman, no opening of furnace doors, no dirt, no coal going in, no clinkers or ashes to be seen anywhere. A turn of the hand regulated the terrible flame that seemed trying to overpower the limits of the furnace, and another turn of the hand brought the fire down to a quiet little flame a foot or two long. During the forenoon occupied by the test about 20 gallons of crude oil were consumed, and it was estimated that with oil at one dollar per barrel this fuel was equivalent to coal at six cents (quantity not stated) in heat-producing value, other things being equal. But other things are not equal by any means, the journal referred to declares, and everything is in favour of oil as against coal. The labour and the expense of "firing up" are dispensed with, and the engineer can regulate the flame as he does the steam in his engines. The danger from sparks and flying cinders is entirely done away with. The space occupied by oil, as compared with an equal

quantity of coal, is very much less, and this much is gained for cargo. Further, the wear and tear upon boilers, grate, bars, &c., is infinitely less; and, it seems scarcely necessary to add, the comfort of passengers is greatly enhanced by the absolute freedom from dirt of all kinds. It is urged that to ocean-going steamers this device must prove of great value. A tank of oil situated at a remote end of the ship would hold fuel sufficient for a double trip and supplant the great coal-bunkers, with their attendant dirt. It is also maintained that the new furnace is full of promise for railway locomotives also.

THEATRICAL COMMERCE OF MILAN.

Consul Colnaghi gives some interesting information respecting the position of Milan as an important central theatrical agency in connection with the great Scala Theatre. It is calculated that the circulated capital yearly employed in the theatrical commerce of Milan exceeds 6,000,000 lire, and that owing to its being able to be turned over several times in the year, the accruing direct profits may amount to 1,000,000 lire, while the indirect gain to the city is about as much more. Milan maintains 32 principal theatrical agencies, at which artists are engaged for the theatres of Rome, Naples, Turin, Florence, &c., as well as for the principal houses of Europe, India, and the British Colonies, Egypt, and North and South America. During the seasons of 1875-76 engagements were made at these agencies for 723 chorus singers (520 males and 203 females), of whom 18 were for Covent-garden, 18 for Drury-lane, and 10 for other theatres in the British Isles. The average annual number of musicians engaged by the Milan agencies for the Italian theatres only is 420; if to these are added the performers provided for foreign theatres, as well as those engaged for the different watering-places in Italy, the total number would hardly be under 1,000. The trades connected with the theatres are established in Milan, and number about 85, the principal being stuff and mercery dealers, dyers and printers, wig makers, embroideresses, spangle-makers, &c. The manufacture of silk tights forms an important branch of trade. It is probable these houses give employment to about 1,000 workpeople. With the exception, however, of certain special trades, the larger firms are not exclusively engaged in theatrical business. The "Sartoria Lamperoni," at present attached to the Scala Theatre, spends on stuffs and wages about 400,000 lire per annum, and has two dyers in constant work. An important branch of work for the different theatrical tailoring establishments are the foreign orders, which are chiefly given through the city theatrical agencies.

Milan contains seven music publishers, employing 360 persons, 14 musical and theatrical journals, 13 dancing masters and mistresses, while 16 ballet masters and composers of ballets have their residence in the city. The annual engagements of ballet masters, mimics, and ballet dancers, male and female, for Italy and abroad, amount to 500. At the female choral school of singing attached to the Scala Theatre and supported by the municipality, 158 students were entered between 1864 and 1875. The pupils of this school are always able to obtain higher remuneration than other chorus singers, and some of them are honourably engaged in singing principal parts. The free school of dancing, originally a Government institution, is now maintained at the expense of the commune. The total number of pupils is between 50 and 60. The principal season at the Scala is in the winter; there is occasionally a short second season in the autumn. Towards the expenses the municipality grants a sum of 150,000 lire per annum, the proprietors of the boxes tax themselves to the amount of 18,450 lire, besides which the town provides, in great part, the *corps de ballet*, the municipal band for the stage, &c., so that the present subsidy would represent a sum of about 200,000 lire. Milan, which has always favoured the fine arts, is not without institutions for imparting instruction under this head. The Royal Academy of Fine Arts, with 27 professors, has 1,452 students, including the elementary and upper schools of design, with respectively 759 and 74 students, the elementary school of figure drawing (206 students), and the elementary school of architecture (152 students). The Royal Academy of Music (R. Conservatori di Musica), founded by Napoleon I, still maintains its reputation, and gives a musical education, vocal or instrumental, to 271 students (155 males and 116 females). Various dramatic academies are also in existence with the object of promoting a love for the stage.

THE FRENCH CENTRAL SCHOOL OF ARTS AND MANUFACTURES.

This important institution—a history of which, by Professor Comberousse, has recently appeared, on the occasion of its seeking new premises—was founded in 1829 by private initiative. Of the group of eminent men with whom it originated, M. Dumas, the well-known chemist, alone survives. The school has steadily improved in its management from the outset, and the number of students has risen from 140 in the first year to 550. With much skill and energy M. Lavallée directed the institution till 1862, when he was succeeded by M. Perdonnet. In 1857, when the number of students had risen to 475, and the school was highly prosperous (the net income in that year began to exceed 100,000 frs.), M. Lavallée, refusing brilliant offers from an association of old students, proposed to hand over the institution gratuitously to the State. This was carried out, and soon after important improvements were introduced; among others, the candidates for admission were classed according to the results of an entrance examination. They had been previously examined simply for admissibility. From its foundation to the present year the school has furnished industry with 4,054 engineers, 552 of whom have been foreigners; all these have gained the engineer's diploma. The total number of students admitted is 7,266. It will be readily conceived what an influence the school must have exercised on French production and the international relations of the country. Especially in the construction of railways in France, since 1835, has its influence been apparent. The council of the school, foreseeing this field of activity, in 1834 appointed a special course of lectures on railway constructon - the first course of the kind in Europe. In 1863, among former students of the school, were 28 railway managers and *ingénieurs en chef*, 79 principal and 56 ordinary engineers. Through the special education provided in the school, French manufacturers were enabled to pass without shock from the system of universal to that of limited protection; and a large number of iron founders, machine makers, farmers, manufacturers of chemicial products, sugar, paper, &c., have gained their scientific knowledge and skill from the Central School. The reputation it acquired led to the formation of similar schools elsewhere, among which comes first the celebrated Polytechnicum of Zurich, founded in 1856, and numbering now nearly 1,000 students (it has now a yearly grant from the Federal Government of 367,000 fr.). Then there are the School of Arts, Manufactures, and Mines, of Liege, founded in 1837, the Polytechnic School of Dresden, the Berlin Royal Institution of Arts and Manufactures, the Polytechnic Schools of Vienna, Munich, &c. Russia has the Imperial Technical School of Moscow, rejoicing in an inalienable capital of 10,000,000 fr., and an income which, in 1877, was 739,000 fr. The United States, which, in 1862, had not a single technical school, have now more than 30,

the endowment of which exceeds 50,000,000 fr. The Paris school, whose lease of its present confined quarters (the Hotel do Juigné) expires iu five years, is going to remove to the ground now occupied by the St. Martin Market, which will be suppressed. It will here benefit by nearness to the Conservatoire des Arts et Métiers. The piece of ground will be hauded over on January 1, 1881, and it is hoped the new edifice will be completed by November, 1884.—*Times.*

CORRESPONDENCE.

HOUSE SANITATION.—VENTILATION OF SEWERS.

The August 22, and September 19, numbers of your *Journal*, both contain articles ou the above subject. All writers on the subject travel on the same road to a certain point, and theu they diverge. The road on which they travel together extends over the distance, and only so far, of admitting the deleterious nature of sewer gas; as soon as they begin to talk about the remedy they at once part company.

In the August number Dr. Brown, Medical Officer of Health for Bacup, gives quite an array of cases, which have come under his own observatiou, ranging from simple abscess to typhoid and diphtheria, which had been caused more or less by the poison of these gases. Such a story could be told by every observant medical officer in the kingdom. Indeed, the effects are now so well known and admitted, that the very knowledge seems to have bred a certain carelessness, which will require the sacrifice of some royal personage before we re-awaken to the fatal facts of the case.

But, now, as to the remedy. After reading the lecture of Prof. Corfield, in your August uumber, about water-closets, sinks, and baths—arrangement of pipes, traps, &c., I said to myself "can this system which is so murdered with details, which depends upon so many nick-nacks for its right conditions, which knows no end of improvements which are only mere tinkerings, and which we find in every day life to be fraught with danger, can this be the outcome of all our scientific knowledge?" Verily, we seem as far from the solution of the problem as any of our forefathers, and a great deal farther than the Hebrews were, for the Pentateuch gives us abundant evidence of the high sanitary attainments of the legislators of those days. It is admitted by all (except the makers) that we have not yet got a perfect trap, or rather, I would say, a "safe" one, for doubtless the "safe" one will be the perfect one; but there is not one in use which I would have in communication with my bedroom; aud, ou this accouut, men have been rubbing up their brains to find out, if not a safe trap, yet some apparatus or appliance which would make the traps we have somewhat safer. And now we come to the article of Mr. E. G. Banuer's in the September number.

After reading that article, I was forcibly reminded of some remarks of Professor Huxley's at the recent British Association meeting at Sheffield. Some time ago the Professor introduced his child Bathybius iuto the world with great promise, but he coufessed that Bathybius had uot verified the promise of its youth; that applies with equal truth to the cowl. In my opinion the "cowl," which is to ventilate the soil pipes and others, is only another device which cau have no practical effect in removing the evils we complain of. Let us look at the matter in a sensible way. We have large sewers full of sewer-gas; we have also a number of drains between the sewers and the houses, containing the same poison; both on account of the specific gravity of these gases and of the temperature of the houses, there is a tendency for them to find their way into the houses, and the object of sanitarians and others is to prevent them. Now, how is it to be done? Well, up to this time, it has not been done by any sort or manner of trap, pan, cowl, or any other mortal thing. I am speaking now from seven years' daily experience as a Medical Officer of Health, and I say there is not one that I would trust. Are we then powerless, and must we submit to this as the inevitable? Certainly not. But what we cannot do at the house end safely, we can do at the other or distant end. Why be constantly perplexing our poor heads about the traps and pans, &c., when the remedy is quite in the other direction? Take away the sewer-gas by some other channel, and then it will not bother the traps, pans, &c., and this is common seuse, and according to every day experience in other matters. Do we go on tinkering with any evil when we cau stop the cause? Prevention must be better than cure, and very much better where no cure is possible. The only plan I ever heard of that will accomplish this is the system of ventilating sewers and drains, and by connecting the main sewers of a town with the furnace of a steam boiler belonging to a factory, brewery, steam laundry, saw-mills, or any other place having a boiler of moderate size. In Halifax the Corporation have made a number of these connexions, but not sufficient for the whole town; where, however, they are made, they answer the most sanguine expectations. The same remarks apply to Oldham, West Vale, Elland, and Blackpool, and to such institutions as Smedley's, at Matlock. At any of these places, the *modus operandi* can be seen, and the results ascertained. Speaking in round numbers, about 1,000 cubic feet of air are drawn through one of the ordinary connexions per minute; of course, with a connecting-pipe of larger dimensions, more would be drawn out of the sewers. The priuciple is simple, the application cheap, aud the results most satisfactory. With this constaut "draw" upon the sewers and drains, the pressure is entirely removed; so that it matters little about the traps and pans, as they become of secondary importance. Of course, I admit there may be places where this cannot be applied, but I think they are very few indeed. When the foul gases have been drawn through the fires of a boiler in this manner, they are turned out of the chimney-top of the most innocuous nature; but the "cowls," supposing they act at all, bring out the noxious gases near the bedroom windows, and must be, to this extent, a source of danger; and why have the slightest risk of this kind, when the largest sewer iu the metropolis can be as effectually cleared as a small drain? Allow me to join Mr. Banner in his coudemnation of the openiugs or grates iu the streets, and I see the *Lancet* has also been hitting very hard at them, but not a bit harder thau they deserve; they are silly in the extreme, powerless to do good, aud productive of mischief. This I have seen repeatedly.

Just as I was writiug this, I got the September 19th number, iu which is au article ou the same subject by Mr. J. G. Winton, who reviews the differents methods of ventilating sewers. I am somewhat at a loss to reconcile the various parts of Mr. Winton's paper. He begins by sayiug "that the furnace systems for the ventilatiou of coal mines has now become obsolete," as the rarefied air was uot sufficient of itself to create a draught; and again he says, "very little has been done to create an in-draught iuto our maiu sewers, dispersing the vapours from the subways far overhead." Now, I couteud that one will follow the other, not as a mechanical, but as a natural cousequence, and Mr. Wintou not only admits this, but explains it in the following words: "In warm weather, with a minimum flow of water through the sewers, the gases rise very sluggishly." The "sun" is the furnace as it were, and the sewers being of lower temperature than the atmosphere, the cold air in the sewers rises through the open gratings. In the winter months our

houses act as the furnaces, and as we try to make them as snug as possible by reducing all indraught through window fittings and doorways to the minimum, the open gratings fitted to the main sewers, then act as feeders, sweeping a cold current of air through the sewers, which carries tho foul gases along. Here, then, we have both the principle and the *modus operandi* laid down. With regard to the external sewers, the "sun" is the furnace, and for the smaller or partially internal, our houses, he says, "are the furnace," and both act on the same principle, that is the rarefied air ascends, and as nature abhors a vacuum, it is at once replaced by cold air. The difference in temperature and density is nature's mode in causing the disturbances which are so often beneficial in the atmosphere. Whether this vacuum has to be made by a suction fan, or by the connection of the sewers to the furnaces of steam boilers, is now the question. I see no reason to doubt that a suction fan of certain dimensions will exhaust a certain sewer area. The thing is quite feasible, but the two objections I have to it are these:—First, it will require motive power of some sort, which will cost something, and, secondly, it would have no action whatever on the nature of the gases; and I might add a third, viz., that the fan itself will be costly, and will be subject to daily wear and tear and occasional breakdowns, but in the furnace, or Stott's system, none of these things apply—there is nothing mechanical to get out of order; the motive power is the exhaustive power of the strong draught of the chimney and furnace. I will here quote Mr. Winton's own words on this point; he says "the furnace system for promoting ventilation we all know to be a very expensive plan, unless we can utilise, as in large manufacturing districts, the numerous furnaces under steam boilers. This plan has, no doubt, certain advantages in being able to deodorise the gases by passing them through the furnace, and then up tall chimneys where the purified vapours would be wafted away into infinite space." Now, it is this very power of utilisation for which we contend, and all the great manufacturing towns have the means ready at hand. Mr. Winton says that the gases having passed through the furnace would be deodorised. I would rather say destroyed, so that whether they are wafted away into infinite space or not, is of no consequence, seeing they are powerless for mischief. In conclusion, if we may judge from what has been done here during the last six years, the time ought not to be far distant when every manufacturer will be so patriotic as to offer his furnaces to the sanitary authorities for the public good, and this would involve on his part neither expense nor trouble.

D. Ainley, M.R.C.S., L.R.C.P., &c.,
Medical Officer of Health, Halifax.

GENERAL NOTES.

American Cutlery.—The *American Journal of Industry*, *apropos* of the growth of this branch of American manufacture, brings out the facts, that while in 1834 all the table cutlery used in the United States was imported from England, at the present time, out of an annual consumption of two and a half million dollars' worth of these commodities, England supplies not more than 8 per cent., and American cutlery now goes largely to Australia, South America, and even Europe. In pocket cutlery, too, American manufacturers have made great progress, though not yet to the extent indicated in the manufacture of table ware. In fixing the cause of this rapid growth, our contemporary holds the secret to lie in the extensive substitution of machinery for the hand labour largely depended upon abroad. "The cutting of the wood for the handles, the finishing of the ivory, the cutting of the steel, the shaping of the knife, the fastening of the handle, the designing of the ornamentation for the handles, the grinding, the finishing of the blades, and numerous other minutiæ, are all done my machinery, most of which is also made in the works."

Wines of Apulia.—Vice-Consul de Martino reports that the exports from Barletta, perhaps the most important of the Italian ports of the Adriatic, consist of grain and wino in full cargoes by steam and sail, loading taking place in the roadstead, the port being only available for small coasting vessels. A great trade might be done in part cargoes of wine, oil, almonds, figs, &c.; but, owing to the want of a good port, proprietors of English, Italian, French, German, and Dutch steamers, who have a regular trade in the Mediterranean from port to port, refuse to send their boats to Barletta, so that commerce with foreign parts of small lots can only take place by sending merchandise to Bari or Naples. The construction of a safe port has been contemplated for some time by the municipality, and would give Barletta, on account of its favourable position, a perhaps greater importance than the neighbouring port of Bari. The attention of her Britannic Majesty's Government should be drawn to the great proportions the exportation of wine from Barletta to France has attained, about 4,000 tons having been exported within the last two months. Many of these wines found their way from France to England, as burgundy and claret, and, if the duty on Italian wines was somewhat reduced, English merchants would soon be convinced that the wines of Apulia could compete with, and perhaps surpass, those of Spain and Portugal.

Underground Waters.—At the recent meeting of the British Association at Sheffield, the fifth report was presented of the committee appointed in 1874 to inquire into the circulation of underground waters, and the extent to which they may be made available for the water supply of towns and districts. The committee state that, as the objects of the inquiry become more widely known, there is increasing inclination shown by engineers and contractors to impart information which accrues from day to day, and that they consider it desirable to continue their labours, until it becomes the duty of some Government department to undertake the charge. They desire to extend their inquiry beyond the Permian, Triassic, and Jurassic rocks to all permeable formations yielding supplies of potable waters. A large amount of valuable information has been collected in the Midlands and in other districts, of works in progress which will be reported on next year. The attention of the reporter of the committee (Mr. De Rance) has been specially directed to ascertaining the area of pervious rocks, in each of the river basins of England and Wales, and of the areas of impermeable rocks, overlying permeable formations, and forming "supra-pervious" areas, together occupying an area of more than 25,000 square miles, and capable of yielding an amount of water far in excess of the quantity required for manuufacturing and potable purposes. The impermeable nature of the Severn river-basin is alluded to, and the consequent danger of abstracting a large volume of its waters for Liverpool water supply commented on.

Palm-oil.—That portion of the West Coast of Africa which lies south of the River Volta furnishes us with our principal supplies of palm-oil. Nearly a million hundredweights of this oil are annually imported into Groat Britain, of the value of over a million and a half sterling, its principal use being in the manufacture of soaps, perfumery, candles, and similar articles. Among the natives it is highly valued, both for food (taking the place of butter), for lighting and cooking purposes, and for anointing the head and body. The so-called oil, which is rather a fatty substance resembling butter in appearance, is obtained from the fruit of several varieties of palms, but chiefly from that of the species known as *Elais guineensis*, which grows in abundance on that part of the western coast of Africa after which it is named. So thickly do these trees grow, and so regular and rapid are their supplies of fruit, that in some localities where the regular collection of the produce is not practised, the ground becomes covered with a thick deposit of the oily, fatty matter produced by the ripe berries. Deposits of palm "oil," which may almost be called "mines" of vegetable fat, exist in some parts of the Gold Coast which, if not in themselves worth working, at least practically illustrate the natural wealth of the country in such productions, and indicate its undeveloped resources. These "mines" would probably not repay the cost of exploration, as the palm-oil is apt to become rancid and valueless for its general uses after long exposure, though for such purposes as candle-making these deposits might still be valuable.—*The Colonies and India.*

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RECENT ADVANCES IN TELEGRAPHY.

By W. H. Preece,

Electrician to the General Post-office.

Lecture I.—Delivered Monday, April 21st, 1879.

It is intended that these lectures shall be confined almost entirely to the narration of the recent advances of telegraphy in England, for, to extend the survey to other countries would compel either the inquiry to be circumscribed or the lectures to be extended. The latter is impossible, and the former is undesirable. Moreover, addressing, as it is believed, a non-technical audience, it is advisable to eschew science and theory as much as possible, and to confine the subject to such simple elementary facts as will bring the whole within the comprehension of all. This will occupy all the time at my disposal.

Ideas are conveyed from mind to mind by means of language. Language is either spoken or written. Speech is composed of certain elementary sounds which are vowels and consonants; and written language is composed of certain elementary symbols which, in European languages, are letters and numerals. Telegraphy is the art of producing these elements of language at a distance, and when this is done at places beyond the direct reach of the ear and the eye, we call in the aid of electricity, and reproduce these elements by means of electric signals. Hence electric telegraphy.

Now, to comprehend fully how electric signals can reproduce the elements of language, even on the other side of the globe, with the accuracy, rapidity, and facility of the present day, the following questions must be answered, viz.:—

1. What is electricity?
2. How is it produced?
3. How is it conveyed from place to place?
4. What is an electric signal?
5. How are these electric signals utilised for the reproduction of speech and language?

The lecture to-night will be confined to answering the first two questions. If we survey this universe in which we live, and move, and have our being, we can reduce everything objective or external to ourselves to matter and to motion. The chemist has reduced matter to nearly 70 simple elements, and the physicist has reduced the motion of the molecules of matter to several modes or forms, among which we enumerate light, heat, magnetism, and electricity. The conception of motion, however, implies the existence of force—of that which produces, or tends to produce, motion—and the application of force to matter, or to the molecules of which matter is composed, means something done, motion produced, or resistance overcome. This something done is called work, and the power to effect work is called energy. Hence, all modes of motion are forms of energy, and, therefore, electricity and magnetism are, like heat and light, mere forms of energy, and, in all their effects, and all their phenomena, we have, in one place, the exact equivalent of work done, or of energy expended, in some other place.

In this box, there exists a store of energy (a Grove's battery). It is, at present, quiescent; it is in a potential condition—like the spring of a clock—ready, on being released by the will, to produce active effects, which are called *kinetic*.

Experiment 1.—Let us make a connection with this platinum wire. Instantly, the energy leaps into activity, throwing the molecules of this wire into that violent motion which we call heat, accompanied by light.

Experiment 2.—The energy is now brought to play upon these two pieces of carbon. Again we have heat, but this time accompanied with more brilliant luminous effects.

Experiment 3.—Next the energy is allowed to pass through this mixture of water and sulphuric acid—coloured to make it more evident—and instantly it forces asunder the elements of the solution into their elementary gaseous forms, oxygen and hydrogen.

Experiment 4.—Now the energy is made to flow around this bar of iron, in which it evokes that peculiar form of energy called magnetism, whereby we are able—(*Experiment* 5)—to attract nails, to hold up iron bars, and—(*Experiment* 6)—to produce attraction and repulsion.

In this way various physical and physiological effects can be produced, all of which are mere reproductions of that energy which has been made potential in the battery, and has become kinetic in the circuit—the technical term applied to the path along which the energy, in its active electrical form, flows. This flow of electrical energy is called the current, and its strength or magnitude depends upon the quantity of electricity that has been thrown into motion in a given time, and this, in its turn, depends upon the potentiality of the energy setting it in motion, and on the resistance or obstacles opposed to its transference. Hence the existence and strength of an electric current simply depends directly upon the energy producing it, and inversely on the resistance opposing its transference.

The energy producing a stream of water is the head or difference of level (difference of potential energy), and the quantity of water flowing to turn a turbine, or work a mill, depends directly on this head, and on the dimensions of the conduit through which it flows. The energy producing a gale of wind is the difference of pressure between different points on the earth's surface. The energy producing a flow of heat between two points is the difference of temperature at those points. Now, the energy that produces a flow of electricity,

analogous to differences of temperature and differences of pressure, is the difference of electric potentials or electro-motive force, an extremely appropriate and convenient term, and one which will be probably used a great deal during the lectures. Hence the electric potential of a point is simply the potential energy of electricity at that point. It is a clearly defined and easily measured magnitude, and one that has led to a very considerable increase in our knowledge of the nature and theory of electricity.

Another term that will be used a great deal is resistance. The resistance of matter to the transference of electricity is the same, relatively, as the opaqueness of bodies to the transmission of light, or their diathermancy to the flow of heat. Everything has its own special electrical resistance. When the resistance is small we have conductors, when great, insulators.

The answer to our first question is, that electricity is a form of energy, that it is the exact equivalent of some work done somewhere, that it is sometimes potential, sometimes kinetic. Hence, it is always measureable, and, if we only know the electromotive forces and the resistances, we can always calculate the energy present.

How then is it produced?

Electricity is a dual, or polar force. It always exists in two forms, which are opposite to each other, and which are hence called positive and negative. A thunder-cloud, for instance, is positively, the earth below it is negatively, electrified. The air between them is in a constrained condition, and when the charge becomes too great for the air to resist, we have discharge—lightning—and the neutralisation of these two electrical states; to be repeated when the cloud has acquired a fresh charge of positive electricity.

This is an epitome of what takes place in every electrical phenomena. Positive and negative electrical conditions are produced, and are then neutralised. If the action be sudden, we have sparks, shocks, thunder and lightning; if they be so rapid as to be continuous we have currents.

Now, whenever two dissimilar bodies are brought into contact, energy is developed at their point of contact. If, after contact, they are forcibly parted, the one body will be found negatively, the other positively electrified, or there will be a difference of electric potential between them. Hence static-electricity and the electrical machine. If such bodies remain in contact, we have still a difference of electric potential. If the one be a solid and the other a decomposable liquid, we have also chemical affinity, and the intensity of the chemical affinity is dependent on the amount of this difference. This constantly brings fresh surfaces into contact, and hence we have continuous electrical action going on, or a current produced.

Now, such a converter of energy is called a galvanic battery. Zinc is almost invariably one body used; various chemical solutions the other.

A battery produces electricity by the combustion of zinc as a fire produces heat by the combustion of coal. To obtain heat from coal, however, it is only necessary to light it in the presence of air, whereas to obtain electricity from zinc a special combination of that metal with another metal or conductor and a liquid is required. The liquid must be one which has a strong chemical affinity or attraction for zinc, and the second metal or conductor must be one for which the liquid has no, or very little, affinity. Sulphuric acid in one shape or another is the liquid which is generally used, and the second conductor is generally either copper or carbon. The combustion of coal in air produces carbonic acid gas, which immediately passes away up the chimney and is lost, but the combustion of zinc in a battery produces sulphate of zinc, which remains, and becomes an article of sale. The carbonic acid gas escapes from the fire of itself, but the sulphate of zino has to be removed from the battery, otherwise it would stop its action.

The arrangement of a piece of zinc and a piece of copper or carbon in a liquid to produce electricity is called a cell, and a series of such cells properly arranged is called a battery.

The Simple Voltaic Cell.

Experiment 7.—If a glass jar or earthen pot, say of quart size, be half filled with water, into which one ounce of sulphuric acid is poured, and if a pure zinc rod with a piece of copper wire soldered to it be immersed in the acidulated water, no change whatever will be observed, but if a plate of copper with a wire attached be also immersed, and the two wires be connected together, then the zinc at once commences to be attacked, and bubbles of gas are copiously given forth from the copper like the bubbles in soda water.

As long as the wires or straps attached to the zinc and copper are kept apart, no action takes place, but the zinc has acquired negative and the copper positive electricity; but the moment they are connected voltaic action begins, the zinc is consumed, the electricities are neutralised, and currents flow. The current flows from the zinc through the liquid to the copper, and thence through the wire back to the zinc; the zinc combines with the sulphuric acid, forming sulphate of zinc, and hydrogen is given off on the copper. Hence, in process of time, all the zinc would be converted into sulphate of zinc; but the action of the cell ceases before this can occur; the water will only dissolve a given quantity, and when this point, called the point of saturation, is reached, the sulphate will form in white transparent crystals on the zinc, and isolate it from the liquid. Again, the hydrogen in forming on the copper leaves less of the plate in contact with the liquid, and "polarises" it, as it is called, that is, it causes it to set up an electrical effect in opposition to the prime current; it also reacts on that portion of the sulphate of zinc which is still disolved in the liquid, causing zinc to be deposited on the copper plate itself. The deposit of crystals on the zinc can be provided against by care and attention in any cell, but that of zinc on the copper plate cannot be obviated in the simple voltaic cell; and cells of a different kind have, therefore, had to be adopted, as will be shown hereafter.

This was the form of battery with which Faraday made all his researches, and also that which was made in all the earlier telegraphs in England. The cases were filled with sand (moistened with sulphuric acid) to make the battery portable. But owing to the existence of impurities in the zinc, great local action occurred, which, though checked by being rubbed with mercury—amalgamation—

led to such waste and irregularity, that the introduction of the sulphate, or Daniell's form of the cell, by Mr. John Fuller, in 1852, was a very great step in advance.

In the cell the zinc is called the positive plate or element, and the copper is called the negative plate or element. Outside the battery the copper end is called the positive pole, and the zinc end the negative pole. This seeming contradiction of calling the copper plate in the battery the negative element and the wire connected with it outside the positive pole, and similarly calling the zinc plate the positive element, and the wire connected with it the negative pole, is explained by the fact that the electricity produced by the chemical action on the zinc or positive plate, as already shown, passes through the liquid in the cell to the copper plate, and from the copper through the wire connecting the two plates back to the zinc; thus positive electricity flows from the negative plate, and the wire connected to this plate is, therefore, called the positive pole.

DANIELL'S BATTERY.

Daniell succeeded in removing the hydrogen from the copper by placing the copper plate in a solution of blue vitriol or sulphate of copper, the zinc remaining in dilute sulphuric acid, and the two liquids being separated from each other by a porous material, which, while it checked the mixture of the liquids, did not prevent the flow of electricity. The action of this cell is like that of the simple one, sulphate of zinc being formed in the dilute sulphuric acid, and hydrogen being produced on the negative plate; but the hydrogen at once decomposes part of the sulphate of copper in which the negative plate is placed, throwing down upon that plate pure metallic copper, which keeps it bright and clean, and forming fresh sulphuric acid, which passes through the porous plate to the zinc, and forms sulphate of zinc. The are three kinds of Daniell's battery in common use, viz., (*a*), the ordinary, introduced by John Fuller; (*b*), the chamber, introduced by John Muirhead; and (*c*), the U.K., so called because it was used by the United Kingdom Telegraph Company.

(*a*) THE ORDINARY SULPHATE BATTERY.

A trough 2 ft. long, 4 in. wide, and 5½ in. deep is made of teak and divided into 10 cells by slate partitions; to make it water-tight it is coated internally with marine glue, which is a mixture of india-rubber, naphtha, and shellac; each cell is then subdivided by a porous partition of unglazed porcelain, about ¼ inch thick, which is fixed while the marine glue is hot. A zinc plate is placed in one of these divisions, and a thin copper plate 3 ins. square, in the next one, and so on, until the 10 cells are occupied. The copper plate of one cell is permanently connected with the zinc of the next cell by a copper strap cast into the zinc and rivetted to the copper, which is easily bent over the slate partition.

The last copper and the last zinc plate are each connected to brass binding screws or terminals, which become respectively the positive and negative poles of the battery. To charge a battery, though apparently a very simple operation, it is necessary to carefully observe a certain routine, and for the ordinary sulphate battery the following details are generally carried out.

About 3 oz. of sulphate of copper crystals, which must be in masses of about the size of hazel nuts, are placed in the copper divisions, filling them to about one-third of their height, and pure water (hard water should never be used) is then poured in until it reaches the same level as the top of the zinc plates. A little time is then allowed for the copper sulphate solution to force the air out of and saturate the porous plates, and when this process is observed to be complete, the zinc divisions are filled with pure water to within a quarter of an inch of the top of the zinc plates. As the porous plates will have absorbed water from the copper divisions, they must be gone over again and filled to the same level as the water in the zinc divisions.

The ordinary action of this battery is:—Zinc is consumed, sulphate of zinc is formed, sulphate of copper is decomposed, and pure copper is deposited on the copper plate. If all the materials were pure, and no causes of interference were present, it would simply be necessary to remove occasionally the sulphate of zinc and replace the sulphate of copper; but the solution of sulphate of copper diffuses through the porous partition, the sulphuric acid, leaves the copper and attacks the zinc, for which it has a greater affinity. Pure copper, in the form of black mud, is then deposited on the zinc plate, and the action of the battery is weakened.

Zinc, again, cannot be obtained pure, and the particles of lead, iron, and other matter which are mixed with it set up local action, which is evidenced by the way in which the plate is pitted.

The porous partitions contain impurities—coke and metallic dust—which also set up local action, and cause copper to be deposited upon them.

(*b*) THE CHAMBER BATTERY.

A box 2 ft. 2 in. long, 5 in. wide, and 5¾ in. deep is made of deal, without any partitions. Five vessels of glazed porcelain or ebonite, forming 10 cells, are fitted into this trough.

Into each cell is put a porous earthenware pot, in which the copper plate is placed. The size and arrangement of the plates and the mode of fitting, charging, and maintaining the battery, are precisely the same as in the ordinary battery. In many places, the wooden box is dispensed with, and the earthen "chambers" are simply ranged on the shelves or racks of the battery room, but always covered with some protection to check evaporation. This plan of placing the cells without casing on shelves is convenient for increasing battery power, as two, four, six, or any other number of cells can easily be added at any time. The chamber battery offers every facility for cleaning, and it is more easily handled than the ordinary form; cracked and imperfect porous pots are very easily replaced, but there is more local action, and it is, therefore, more wasteful. This wastefulness is, however, checked to a certain extent by saturating the porous pot, except at the part immediately opposite the zinc plate, with melted paraffin, and thus preventing diffusion, the principal cause of waste. Great care must be taken to keep the non-saturated side of the porous pot opposite the zinc plate.

(*c*.) THE UK BATTERY.

This battery takes its name from the initials of the late United Kingdom Telegraph Company,

who used it to a very large extent upon their system, prior to the transference of the telegraphs to Government.

In this battery each cell is a round earthenware jar, 5 in. high by 4½ in. wide, holding two pints. The porous pot is saturated with paraffin for half an inch at its base and at its top. It sometimes stands upon a gutta-percha tripod. The copper plate is curved and fixed just outside the porous pot. The zinc is circular and weighs 2¼ lbs. Crystals of sulphate of copper are placed inside the copper, and the cell is charged and cleaned in the same way as the cells of other forms of Daniell's battery. The cylindrical shape of the copper and zinc plates offers a very large surface for chemical action, and at the same time minimises the internal resistance, thus increasing the strength of the current, which of course is a great advantage in the working of long circuits, especially when the insulation has fallen comparatively low.

Faults Prevalent in Daniell's Batteries.

(*a.*) *Leaky cells.*—The marine glue chips off, and the joints fail, one cell leaking into another; or the same thing happens with the fixture of the porous cell; or the porous jar itself is cracked. The result is complete loss or great reduction of power. This is easily remedied temporarily by bridging the faulty cell across with a piece of wire or strip of metal.

(*b.*) The porous jar sometimes becomes so hard as to offer sufficient resistance to the current to reduce it greatly. The remedy is the same as in the last case.

(*c.*) The porous jar is at other times too soft, and causes an unequal diffusion of the liquids, so that the liquid in the copper division becomes higher than that in the zinc division. This can be checked by a little acid, but time is the best cure. If time fails to work a cure the jar should be removed.

(*d.*) Dirty connexions are the most frequent source of failure, and cleanliness is the only cure.

(*e.*) The zinc plate becomes much corroded at the level of the liquid. This is due to the presence of too much free sulphuric acid, the result of some local action. This, however, is a very rare fault, and one that soon ceases.

(*f.*) Local action works out one cell before all its neighbours. The copper division is found to be full of clear water. It should at once be supplied with crystals. Indeed, the liquid should always be blue.

(*g.*) Occasionally a battery makes earth on a damp support, but this can always be guarded against by care.

Gravity form of Ordinary Battery.

As the porous cells are costly and troublesome, Mr. Cromwell Varley proposed to dispense with their use by taking advantage of the different specific gravities of sulphate of copper and sulphate of zinc to keep the two solutions together. He made what is called the "gravity" battery, but our experience of its use in England did not justify its retention in practice, though in different forms it has become very extensively used in France, India, and America.

One of the greatest improvements ever made in batteries was that made by M. Leclanché.

The Leclanche Battery.

The Leclanché battery is made thus:—

Into a glass jar a solution of the ordinary commercial sal ammoniac (which is a combination of hydrochloric acid and ammonia) is poured. A zinc rod or plate, into which a connecting tinned iron wire has been cast, is then placed in the solution, and a plate of carbon surrounded by a mixture of broken gas-carbon (or coke) and peroxide of manganese, is fixed in a small porous pot at the top of the jar. To make an attachment for the terminal the top of the carbon plate is capped with lead, which makes good metallic contact with the carbon, and is not liable to be attacked by ammonia, as brass would be. The carbon plate is then dipped in melted paraffin to fill up its pores and to check the exclusion of the liquid by capillary action.

Lastly, the wire, the top of the zinc rod, and the lead cap of the carbon plate are covered with pitch, ozokerit, marine glue, or some other compound, to protect them from local action.

The Action of the Battery.

The action of the battery is to dissolve the zinc and form zinc chloride, and some other salts of zinc which are not soluble in water but are soluble in a solution of sal ammoniac and water; to reduce the peroxide of manganese to a lower oxide; and to form ammonia, which is given off as a gas. Thus, after a time, new zinc will be required, the sal ammoniac must be replaced, and the porous cell which contains the peroxide of manganese must be renewed. When the solution of sal ammoniac becomes too weak to dissolve the zinc salts, they form themselves in crystals on the zinc rod and porous pot, and if the solution becomes too highly charged with these salts (super-saturated) the crystals form in the substance of the porous pot and crack it. This is prevented by a periodical renewal of the sal ammoniac solution.

There is no local action or waste of material when the battery is not in action, so that if the evaporation of the liquid is prevented it may be allowed to remain untouched for months without losing power. The time the battery will last is entirely dependent on the amount of work it has to do.

It polarises so quickly that it should not be employed for local battery purposes or for double current circuits, or circuits where permanent currents are used.

Faults prevalent in the Leclanche Battery.

The cracking of the porous pot, due to the formation of crystals in its pores. The corrosion of the connecting iron wires, due to the action of ammonia. The disconnexion of the connecting wire of the carbon plate, due either to the lead cap making imperfect contact with the carbon, or to the formation of salts of lead between the lead and the carbon. The cracking of the glass jar, due to imperfect annealing.

The Leclanché possesses a great advantage over the Daniell battery, where only a comparatively small amount of work is required, because the Daniell, when left to itself, becomes weakened by local action to almost as great an extent as if it were in work, which is not the case with the Leclanché. But the Leclanché, if worked hard,

rapidly polarises and becomes unfit for use. Where a moderate amount of work is required, it is an admirable battery, and requires a minimum amount of attention.

The "Gravity" Form of the Leclanche Battery.

This is designed specially to utilise troughs which have been made for Daniell's batteries. The porous divisions are removed from the trough. The carbon plate is inserted, passing through the zinc plate. The bottom of the cell is charged to nearly half its height with crushed gas retort carbon and peroxide of manganese. Sal ammoniac is placed on the zinc plate, and each cell is nearly filled with water.

The action of this battery is in every respect the same as that of the other form of Leclanché battery. This battery has been recently introduced, and is found to be very effective.

The Bichromate Battery.

Mr. John Fuller has recently made a further step in advance in the introduction of a very powerful battery called the Bichromate battery. Each cell consists of a glass or stoneware jar, either of a quart size or of the same size and pattern as that used for the UK form of Daniell's battery. Inside this jar is placed a porous pot; the zinc is placed in the porous pot, and the negative plate, which is of carbon, is placed in the outer jar; the zinc is a small block of a pyramid shape, fixed at the end of a stout copper wire, both being well amalgamated, to which the binding screw is attached. Each plate being surmounted by a terminal, any number of cells can be connected together in series.

To Charge the Battery.

In the outer jar are placed three ounces of bichromate of potass and four ounces (or one measure*) of sulphuric acid.

In the porous pot are placed two ounces or measures* of mercury. Both are then filled up to within two inches of the top with water. As the mixing of water with sulphuric acid produces great heat, sufficient in fact to fracture a glass jar, a better plan than placing first the sulphuric acid and then the water in the jar, is to prepare a solution of sulphuric acid in an earthen vessel beforehand, and to pour this solution into the jar. The strength used is about one part sulphuric acid to nine parts water. The acid is placed in the earthen vessel first and the water then poured in; sulphuric acid should never be poured into water.

The zinc and its copper rod is then amalgamated afresh by dipping it into mercury covered with diluted sulphuric acid, and rubbing the mercury over the metals until they are quite bright; and the terminals and contacts between the different cells are made bright and clean; the battery will then soon be ready for work.

The Action of the Battery.

The sulphuric acid passes into the zinc cell, and when the plates are connected, attacks the zinc and forms sulphate of zinc, while the hydrogen reduces the bichromate of potass to a lower form, called the dichromate. The mercury keeps the zinc perfectly amalgamated, so that no local action takes place; there is a secondary action in the battery when the solutions become saturated, which results in the formation of beautiful dark violet crystals of "chrome-alum" on the carbon plate. This is a double salt, a sulphate of chromium and potassium.

It would naturally be thought that the copper being directly connected to the zinc rod would cause local action to be set up, but this is prevented by capillary attractions, the mercury gradually rises up from the bottom of the cell, and coats the copper wire with a thin film of mercury and dissolved zinc, wherever local action could take place.

The desiderata of any source of electricity for telegraphic purposes are, efficiency combined with durability and economy. Every battery has its own certain work to do, and it must be specially adapted for that work. Uniformity is very desirable in practice, but efficiency must never be put on one side for uniformity. Hence it is that, for certain purposes, where weak continuous currents are desired, the Daniell is incomparable, and, for other purposes, where sudden, powerful blows are needed, the Leclanché is *facile princeps*. Again, where weak insulation and long lines render working difficult, the Bichromate steps in to supply a want.

I have been surprised, on examining battery arrangements in other countries, especially in America—so enterprising and so 'cute—to see how far behind they are.

Batteries differ from each other in their electromotive force, internal resistance, economy, and constancy. They are required for giving either momentary or prolonged currents. They are required to work short or long lines. They may have comparatively little work to do, as at a small post-office, or they may be hard pressed, as when 20 cells work 10 distinct circuits, on what is called the "universal" plan.

Now, each battery has its distinct qualifications, and fulfils its proper duty.

The electromotive force of the ordinary Chamber and U.K. is the same, and if we take it as unity, then the Leclanché is 1·4, and the Bichromate 2. That is, 10 Bichromates, 14·5 Leclanché's, and 20 Daniell's have the same electromotive force.

The resistances of the forms in ordinary use are as follows:—

	Ohms.
Ordinary	10
Chambers	6
U.K.	4
Leclanché	3
Bichromate	2

The constancy of the three forms of Daniell is, for any reasonable period, perfect, that is, a current of exactly the same strength can be maintained from them for hours, or even days. But the Bichromate is not so steady, and the Leclanché is very variable indeed; hence the latter can only be employed where momentary currents are used.

The cost of the maintenance of the batteries just mentioned is shown by the following table:—

	s.	d.	
Leclanché	0	4	per cell, per annum.
Ordinary Daniell	0	6	,, ,,

* Measures are supplied for this purpose.

	s.	d.	
Chamber ,,	1	0	per cell, per annum.
U.K.	1	1	,, ,,
Bichromate	1	0	,, ,,

The relative cost is, however, different, for owing to the greater electromotive force of the Bichromate and Leclanché, a fewer number of cells are required to do the work. Indeed, one-third of the number of Daniell's cells are all that are needed of Bichromates, and two-thirds of Leclanché's.

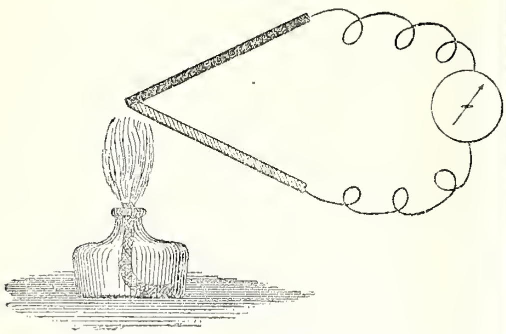
There are now in use at the Central Telegraph Station of the General Post-office the following number of cells of the various kinds mentioned:—

	Cells.
Bichromates	1,650
U.K.'s	2,450
Chambers......................	12,750
Ordinary Daniell's..............	500
Leclanché's	500

Or, say, about 18,000 cells in all.

There are other sources of electricity, besides chemical action, which are available to the telegraphist. Heat, for instance, becomes readily converted to electricity. Seebeck discovered, in 1821, that if two dissimilar metals be connected together, and heat be applied to their point of junction, a current will flow (Fig. 1), very weak, it

Fig. 1.



is true, but subsequent investigators have shown that if many of these couples be formed, and the most suitable metals or alloys be used, currents can be produced powerful enough to work telegraphs. Thus Clamond, by using an alloy of antimony and zinc for the negative metal, and tinned sheet iron for the positive one, produced a pile of considerable power. It was heated by an ordinary Bunsen flame, but coke and charcoal have been used. Many were tried at the Post-office, but they all failed after constant use, and experiments in this direction have ceased.

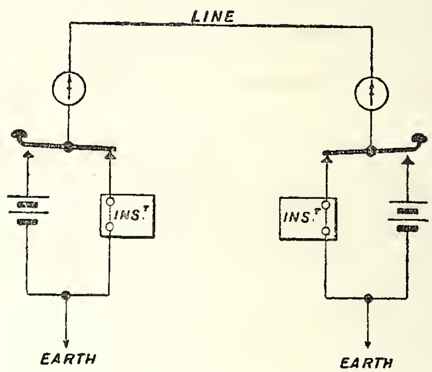
The most promising source of electricity, where steam or water power is abundant, is the dynamo machine, so prominent just now for electric lighting purposes. Here we have the direct conversion of motion into electricity. Faraday showed, in 1831, that the mere motion of a closed conductor in the field of a magnet produced a current of electricity, and Wilde, Gramme, Siemens, and others have recently utilised this principle to produce machines of great power.

I have a small Gramme machine here, which will illustrate to you this mode of generating electricity, but no experiments on any large scale for telegraphic purposes have as yet been attempted with it. The scarcity and expense of these machines have prevented this, while their prospective value for telegraphic purposes scarcely justifies much expenditure. The principle is used on a small scale with Wheatstone's A B C telegraph, and it will be fully described when that apparatus is explained.

A few words must be said, in conclusion, about the economical application of currents, or arrangement of batteries.

Batteries can be fitted up either on the open (Fig. 2) or closed circuit (Fig. 3). In the former,

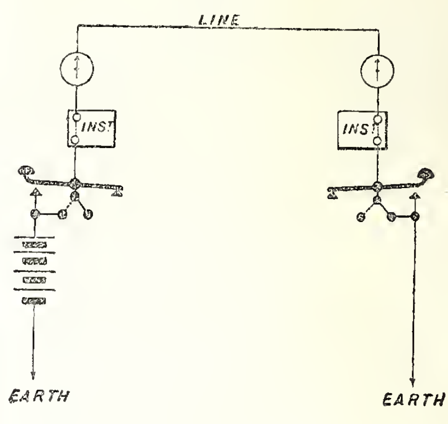
Fig. 2.



OPEN CIRCUIT

no current flows except when it is wanted to make signals; in the latter, the current is always flowing, except when it is broken to indicate signals. There is a combination of the two, by which the

Fig. 3.



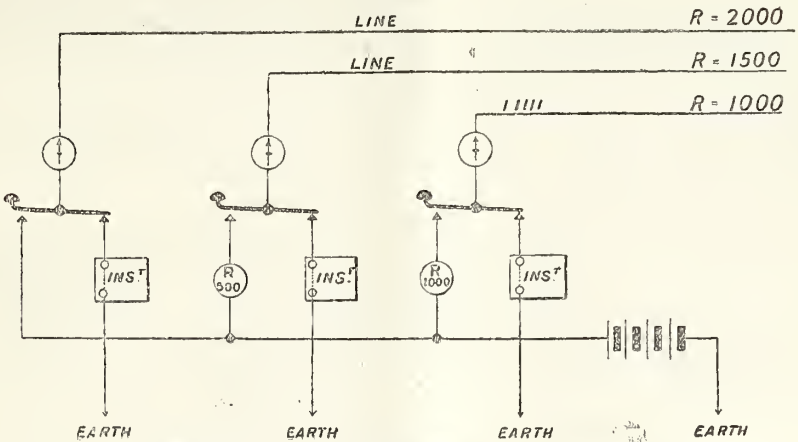
CLOSED CIRCUIT

current is usually flowing; but it is broken for the purpose of signalling, each signal being made by its being completed again. The closed circuit requires only one battery, and that may be at one place only.

Hence, if there be many stations on one wire, it would appear economical to use the closed circuit. But the waste is considerable, and the number of cells needed much greater at the one station. Practical experience, the true test of such a question, has effectually solved it for England, and has shown that the open circuit is decidedly the superior. In America, the closed is almost universally used.

The "universal" plan of working many circuits from one battery has already been alluded to (Fig. 4). This is a very economical mode of working. When a battery possesses low internal resistance and considerable electro-motive force, it is just as easy to work 10 or 20 circuits from it as one or two. Experience has, however, taught us that it is not advisable to group circuits together, for this mode of working, in greater numbers than five, and it is

Fig. 4.



UNIVERSAL BATTERY SYSTEM

also advisable, in case of failure, never to have less than two distinct sets of batteries at one station. This mode of working is very general in America, and has been frequently attempted on a small scale in England, but lately it has been very extensively adopted throughout the postal telegraph system, and the economy effected thereby has been very considerable. Moreover, the probability is that the result is beneficial because it ensures batteries of great power and low resistance being maintained in a very high state of efficiency.

It is hoped that at the next meeting it will be possible to explain how it is that the currents produced from these batteries are conveyed from place to place, to produce those electric signals that enable us to reproduce speech or language.

MISCELLANEOUS.

TOUGHENED GLASS SLEEPERS.*

The glass is moulded into various forms to suit the different requirements, the cooling of the glass being so regulated that the radiation from each point of the surface corresponds to the thickness of the glass, thus enabling the casting to be equally affected throughout when undergoing the tempering or hardening process. The regulation of the radiation or absorption of the heat in the thicker parts of the casting is done by having iron moulds hollow, and by circulating cold water or cool air at those points where the glass is thickest, so that the casting cools equally all over.

The mode of toughening the glass is both curious and instructive, affording as it does a complete contrast to that of steel. The glass is heated to a high temperature and then plunged into a bath of cool oil or other liquid, the result being that the glass becomes converted from its own characteristic brittleness to the remarkable tough fibrous material known as toughened or tempered glass; but to produce the desired effect, and obtain the full advantages of the toughening process upon articles of great strength and thickness, Mr. F. Siemens has found that the hardening or tempering can be effected in the moulds themselves: firstly, by carefully protecting the glass from coming in direct contact with the metal mould, to prevent the chilling of the surface of the glass; and secondly, by the use of the hollow moulds before spoken of, for maintaining a uniform temperature all over the castings during the hardening. The temper is modified in these thick castings by passing them through an annealing oven.

The moulds are chiefly protected by layers of wire gauze, perforated metal, or plaster of paris, varying in layers or thickness according to the rapidity and energy required in tempering, with the nature and composition of the glass—this energy being increased at the thick parts of the casting before alluded to by the circulation of cool water or air through the cast-iron hollow mould. So far as experience has shown, all kinds of glass are equally affected by the process.

The toughening process, as well as the hollow moulds, are the patent of Mr. Frederick Siemens, of Dresden, and recently brought by that gentleman to great perfection by the simple and inexpensive means above alluded to. The first cost of this specially prepared material will not exceed that of cast iron, but the specific gravity of glass is only one-third that of iron, and its strength for all practical purposes is as great. A large out-put is anticipated, and in this way it is calculated that the first cost of glass will be considerably less than that of iron; and, by a similar calculation, can be shown to be cheaper than wood. It

* From a Paper read before the Iron and Steel Institute at Liverpool, by Mr. C. Wood.

is asserted that these glass sleepers will, as far as one is able to judge, last a very long time, being neither subject to corrosion nor decay. Under these circumstances, it will be unnecessary here to enter into any calculations to prove the enormous saving that will be effected in the maintenance and renewal of permanent ways. Such a fragile material as glass has hitherto been looked upon as useless for purposes where great strength is required; but impossible as it may sound, the toughened glass is almost as strong as iron, whilst it possesses greater durability. Its qualities certainly deserve a fair trial and investigation, and the time may come when we shall see not only glass sleepers, but glass tools and implements, eaves troughings, or spouting.

Some of these glass sleepers are laid down upon the North Metropolitan Tramway. They are laid longitudinally in 3 ft. lengths, 6 in. by 4 in., and are specially formed on the upper surface to allow of the rail exactly fitting. The average transverse resistance of the sleepers, tested at Mr. Kirkaldy's works in Southwark, supported at 30 in., was found to be about five tons.

Mr. Bucknall, the inventor of the sleepers, proposes to make them out of blast furnace slag under Mr. Bashley-Brittain's process, combined with the toughening process of Mr. Siemens. After describing to the writer the difficulties he has had in getting his experiments carried out in England, the inventor mentioned, among other things, that the glassmakers to whom he applied would not undertake any experiments unless all expenses were paid, and that these manufacturers would not make the moulds or presses for the process, but recommended other firms. On application to the pressmakers, however, he got a quotation asking between £70 to £80; and it was stated that it would take three months to invent, and that he must be responsible for any extra charges made. Under these circumstances, he says, "I gave up in despair; but, having casually heard of the Siemens process, I got an introduction, and was put in communication with Dresden, and within a week found myself at the glass works of Mr. F. Siemens in that city. In another week, a wooden model, which cost 2s. 6d., was produced, and an iron mould made from it, which cost about 30s., and, two days afterwards, I held in my arms the first baby glass sleeper; but, so heavy was this first-born, that it suddenly slipped from my grasp, and fell with a heavy thud upon the flags. I feared for the safety of my darling's carcase, but, upon careful examination, I found it to be unimpaired. There its longitudinal form lay, upon the ground, not dead, but a veritable sound sleeper, still living, and, probably, worth more than a dozen dead ones."

GENERAL NOTES.

Effect of Forests on Climate.—The French Forestry Department, according to the *Polybiblion*, are satisfying themselves that forests directly increase the supply of water in their neighbourhood. From observations at Senlis and Nancy, they have decided that it rains more abundantly in wooded tracts, and that, while the leaves and branches give back the water quickly to the air, they prevent rapid evaporation from the ground, and are thus favourable to the formation of springs.

Oak and Teak.—In 1878 there were imported into Great Britain 60,254 loads of oak, of the estimated value of £354,916, against 120,118 loads in the previous year, being a decrease of 59,864 loads. The various oak-producing countries contributed as follows:—Russia, 3,151 loads; Germany, 25,048 loads; Austria, 3,014 loads; United States, 2,641 loads; British America, 25,402 loads; other countries, 998 loads. Last year, 37,990 loads of teak were imported to Great Britain, against 28,072 loads in 1877, showing an increase of 9,918 loads.—*Timber Trades' Journal.*

British Museum.—It is reported to be the intention of the Trustees of the Museum to use the electric light in the reading-room during the winter months, in order to extend the hours for readers, and to illumine the room in foggy weather. The system will be tried of using a few lamps hung high above the floor level, and diffusing the light by reflectors. The arrangements will be directed by Messrs. Siemens Brothers.

Economic Entomology.—The council of the Entomological Society is authorised by Lord Walsingham and other gentlemen interested in the disease of our native game birds to offer to public competition the following prizes:—£50 for the best and most complete life history of *Sclerostoma syngamus*, Dies., supposed to produce the so-called "gapes" in poultry, game, and other birds; £50 for the best and most complete life history of *Strongilus pergracilis*, Cob., supposed to cause the grouse disease. No life history will be considered satisfactory unless the different stages of development are observed and recorded. The competition is open to naturalists of all nationalities. The same observer may compete for both prizes. Essays in English, French, or German to be sent in on or before October 15th, 1882, addressed to the secretary of the society, 11, Chandos-street, Cavendish-square, W.

Photographic Society.—The Exhibition of Photographs formed by this society for the present year was opened on Saturday, 4th inst., with a private view and *soirée*. The catalogue consists of 404 entries, but most of the numbers represent a series of several pictures. Examples of many different processes are exhibited upon the well-filled walls, which consist of portraits, views of picturesque points in Wales, Scotland, and Ireland, besides a large number of representations of the scenery of foreign countries. A series of views in Demerara (No. 386), show the grand Falls of Kaietur in various points of view, and the inscriptions on the surrounding rocks. The architectural remains of ancient India are also largely represented.

Clamond's New Thermopile.—The *Electrician* says that the workshops of M. Denayrouse have been experimentally lighted by means of the electric lamp of M. Suisse, worked by a thermo-electric battery constructed by M. Clamond. It is found that more than twice as much charcoal was consumed in heating this apparatus than would have been required to produce the same light by means of a dynamo-electric machine. On the other hand, only about 6 per cent. of the total quantity of heat produced was actually converted into electrical work; the remaining 94 per cent. being readily and conveniently available for heating and ventilating purposes. Moreover, it is considered quite practicable to economise one-third of the quantity of fuel which was used in the present experiment.

NATIONAL TRAINING SCHOOL FOR MUSIC.

In consequence of the numerous applications from the public for admission, the Committee of Management of the National Training School for Music have made arrangements to receive private pupils for periods of not less than one year, on the payment of fees. Such pupils will be required:—

1. To pass a test examination to the satisfaction of the principal of the Board of Professors.

2. To furnish the authorities of the school with certificates of birth and health, and with testimonials from persons of good repute as to moral character.

3. To pay, in advance, to the bankers of the school, Messrs. Coutts & Co., Strand, the sum of £40 per annum.

4. To sign an agreement to observe all the rules of the school, and to work out the curriculum of studies appointed by the authorities of the school.

Applications and inquiries should be addressed to the Registrar, National Training School for Music, Kensington-gore, S.W.

JOURNAL OF THE SOCIETY OF ARTS.

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FRIDAY, OCTOBER 17, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RECENT ADVANCES IN TELEGRAPHY.

By W. H. Preece,
Electrician to the General Post-office.

Lecture II.—Delivered 28th April, 1879.

You heard, last meeting, what my notions were of the nature and character of electricity, and how it is produced; and you were shown the various forms of batteries that are used in this country in conveying intelligence from place to place. It was quite impossible, in the time allotted to me for these lectures, to go generally into the question of batteries, or to attempt to describe more than those that are really in use in this country.

To-night we shall take the next branch of the subject, that is, I propose to endeavour to show you how we transfer this electricity from place to place.

Now, the operation can familiarly and popularly be said to be almost indentical to that which conveys water or gas from one place to another. For instance, in this room we have a very pretty sunlight burner, through which the gas has been passed to be consumed and to give light. The gas is generated miles away (I do not know where, because I do not know what company supplies it), and has been transferred from the gas-works, by pressure, through pipes that convey it to this room, and all that we have to do to obtain the necessary light is to ignite the gas, and regulate its passage through the burner, by simply turning a cock. So with electricity. We produce electricity in batteries, such as you saw the other night, and we have to supply, not the pipes, but something very much akin to them, to convey it from where it is generated to the place where it is used. The amount of current that is required to operate a given instrument, can be regulated with the same exactitude and nicety that we can regulate the quantity of gas consumed, and, in carrying out this, we make use of the two simple functions of the current to which reference was made last time, and that is the electromotive force, or the energy producing the current, and the resistance opposed to its progress. We have, therefore, first of all, to find something that shall be to electricity what air is to light; what pipes are to gas; we want something that shall be transparent to electricity, and we are led to conceive two properties of matter; the one called conduction, and the other insulation. Conduction is the term applied (the reverse of resistance) to that property of bodies which enables them to convey electricity, and insulation is that property of bodies which resists or prevents the passage of electricity.

Now, metals in all periods of electrical history (which is a very short one) have shown themselves to be the materials to be used for the conduction of electricity, and substances, such as gutta-percha, india-rubber, glass, porcelain, &c., those best adapted for insulation.

The very first telegraph that was ever practically laid down—not the first that was experimentally used—was that which was put down by Cooke and Wheatstone along the Camden incline, in the year 1837. Three or four years ago, in digging up this incline for some purpose or other, pieces of this old original telegraph were brought to light. We call this the "fossil" telegraph, though its age is only a little more than 40 years. I have a piece of it here. It consists of a piece of wood, of a pyramidal section, with five grooves in it. In these grooves were placed copper wires, each wire being surrounded by cotton steeped in pitch; a tongue of wood was placed over the wires, they were then placed in the ground, and formed the first telegraph.

In 1840, a line was laid down from Paddington to Slough. That line consisted of copper wires drawn through pitch and other compounds, and surrounded by a lead pipe. But it was soon found that the wires so encased in lead and buried became useless. They were taken out of the ground, and were suspended on posts. Here the first insulator used, viz., a goose quill, was brought into requisition. Posts were arranged every thirty or forty yards, and the copper wire was placed inside the goose quill, the latter article in those days being thought sufficient to insulate an electric current. Curiously enough, the experience of the Americans, which commenced in 1844, also began with the use of copper wire, but they used cloth steeped in gum lac as an insulator. Their experience, however, was exactly similar to ours, and was equally valuable, in very soon leading them not only to abandon the use of such primitive insulators, but also to abandon the use of copper wire. Copper expands under the influence of heat. When it expands about 1 per cent., it loses its elasticity, and does not recover itself; takes awkward sags, knuckles into curious forms, and becomes, after a short time, practically useless. It was in those days that we were very speedily led to the use of iron wire, and, for overhead telegraphs, iron wire, from that day to this, has practically remained the material used for the conveyance of electricity. The first iron wire used was of the very best kind that could be obtained, known as the best charcoal wire. It was chosen principally for its strength, and, for all purposes, was quite strong enough, quite good enough, and gave full satisfaction. But, after a time, notions of economy came in; charcoal wire was found to be a little too expensive, and another kind, known as "B.B." (best-best) wire, was introduced, and for a great many years economy reigned supreme, and this ordinary B.B. wire continued in use. Other notions latterly came into play. It has been found that the resistance of iron wire to the passage of currents varies very

considerably. Different qualities of wire of the same dimensions will allow different quantities of electricity to pass through, and, therefore, the telegraph engineer applied his mind and knowledge of the laws of electricity to the examination of the texture of the material used; and by the application of his knowledge of the laws, and by the introduction of electrical tests, the quality of the iron wire for telegraphic purposes has been improved at least 50 per cent. The wire used at the present day is at least 50 per cent. better than that which was used 20 years ago. I cannot give figures showing the progress in this direction, as exact measurements did not commence until 1869 or 1870; but, from a careful examination of the wires that exist now with wires erected in 1844 and 1850, and allowing for the deterioration due to age, the result shows that our present wire is, as I say, 50 per cent. better. The way in which this quality is proved is simply by measuring the resistance of the wire. If you want to measure the length of anything, you measure it in feet or inches. If you want to measure the quantity of liquid to be used for any purpose you have your gallon, quart, and pint, and in every kind of measurement we have some unit or some standard to refer to. Now, in measuring the resistance of wires to the conveyance of electricity we use a unit—a standard to refer to—and this unit is called an *ohm*. It is a very difficult thing to give you an idea what an ohm is. It really is almost an arbitrary resistance, one that, after a careful and exact examination, has proved to form a connection between electricity, heat, mechanical motion, and all the physical agencies. This peculiar quantity, that is called an ohm, is represented by a yard of platinum wire of given dimensions; it is very nearly represented by a column of mercury one mètre long and one square millimètre sectionally high. But it is really a fixed arbitrary standard, to which all our measurements are compared, and it is as difficult to explain as it would be for me to explain to you what an inch or a foot is. Nobody can tell what a foot or a mile is—they are arbitrary standards fixed for measurement. So with reference to this arbitrarily fixed standard of resistance that is called an ohm, although perhaps it is scarcely fair to call it arbitrary, because it really is a scientific unit based upon our knowledge of the units of time, space, and length. Well, the early wire to which I refer, gave a resistance of 20 ohms per mile, The wire which was used in the year 1870, when exact measurements commenced, gave a resistance of 15 ohms per mile. The wire that is now used gives a resistance of under 11 ohms per mile, so that you see how our knowledge of the laws of electricity has tended to improve upon the quality of the wire for conducting purposes. Then, again, a wire requires to have a certain tensile strength, and this is maintained at a certain fixed point where we know it to be perfectly safe. The principal point in which we are interested is its durability. When iron is exposed to the air, the moisture contained in the air combines with the iron and forms rust; the rust scales off, leaving fresh surfaces exposed to the moisture, which again is brought into contact with it, and the rusting process goes on, and would result in the wire being rusted through in a very short time. To prevent this rusting, a process, curiously enough called galvanising (although it has nothing whatever to do with Galvani or electricity) has been introduced. The wire is cleaned by acid, is drawn through a bath of molten zinc, and becomes coated with a thin layer of zinc. Zinc has this property that, when it is once covered with moisture, an oxide of zinc forms which is insoluble, and it remains adhering to the wire, and acts as a perfect protection; and in the clear country (in such country as our South-Western Railway passes through, where wires erected in 1844 are as perfect now as when first put up), wires so coated will last for an indefinitely long period. But when we come in the neighbourhood of towns, where smoke and sulphurous acid gases of different kinds exist, there these sulphurous acid gases combine with the oxide of zinc, and form a sulphate of zinc which is soluble, and gradually disappears, and leaves the wire exposed to the rusting process just described. The result is, that in many places wires will not last more than three years, and in such places new processes have been adapted for protecting the wires. I have here various samples of the character of wires that are used, they vary in gauge according to the distance they have to travel. Where we have very long circuits, as between London and Glasgow, we require wires of small resistance, which enables Glasgow practically to be brought much nearer to London, and in such cases we use wire which is called, in the Birmingham wire gauge, No. 4.

The Birmingham wire gauge is a meaningless thing in itself, but, somehow or other, it has got into the language of wires, and telegraphists can only speak of wire by its number, No. 4, No. 8, or whatever it may be, although it practically means very little; it would be much better if we could introduce the diameter, and speak of wire by its size in thousandths of an inch, or something like that, and that we are striving to do.

Here is a specimen of "No. 4" wire. It has a diameter of $\frac{240}{1000}$ths of an inch, and wire of this kind is used for very long circuits. The next size smaller, No. 8, is $\frac{170}{1000}$ths of an inch in diameter, and is used for distances of about 200 miles, such as from London to Liverpool. For shorter distances, a still smaller-sized wire, No. 11, is used. It is about $\frac{120}{1000}$ths of an inch in diameter. These are really the three sizes of wire now in general use. There is a "strand" wire that is used for crossing over houses, and also a small-sized wire, No. 16, which is used for binding and making joints in No. 8 and No. 11 wires.

The subjoined Table gives the standard particulars of these various gauges. (See next page.)

In places where smoke abounds, and where decay is rampant, we endeavour to protect the galvanised wires by coating them, sometimes with hemp and tar, and sometimes with tape served with a preservative compound of some kind or other. The South-Western Railway was one of the first places where this preserving process was used. The wire erected on that railway was coated with hemp that was well tarred, but it proved an insufficient protection. The hemp rotted; and those of you who are in the habit of travelling along this railway will be familiar with the festoons of this stuff hanging from the wires, which has a very disagreeable appearance. I was asked, only last

Table of Galvanised Iron Wires used for open-air Telegraphic Purposes.

Nominal Size B.W.G.	Diameter.			Weight per Mile.			Minimum Breaking Weight for Standard Diameter.	Minimum Number of Twists in Six Inches.	Maximum Resistance per Mile of the Standard Weight at 60° Fahrenheit.	Constant, being Standard Weight × Resistance.	Weight of each Bundle.		Minimum Weight of each Piece or Coil of Wire.
	Required Standard.	Minimum.	Maximum.	Required Standard.	Minimum.	Maximum.					Minimum.	Maximum.	
	Inches.	Inches.	Inches.	Lbs.	Lbs.	Lbs.	Lbs.		Ohms.		Lbs.	Lbs.	Lbs.
4	·242	·237	·247	800	767	833	2,150	14	6	4,800	90	120	90
6	·209	·204	·214	600	571	629	1,600	16	8	4,800	90	120	90
8	·171	·166	·176	400	377	424	1,075	20	12	4,800	90	120	90
11	·121	·118	·125	200	190	213	540	27	24	4,800	80	112	40
								In 3 Inches.					
16	·066	·063	·069	60	55	65	—	20	80	4,800	28	112	5

Note.—In the case of wire not equalling the minimum breaking weight for standard diameter, as shown in the table, the allowance named below will be conceded in consideration of the number of twists being above the minimum.

For No 4 Wire—for each additional twist 40 lbs. will be allowed, but in no case will a less breaking weight for standard diameter than 2,000 lbs. be accepted.

For No. 6 Wire—for each additional twist 30 lbs. will be allowed, but in no case will a less breaking weight for standard diameter than 1,500 lbs. be accepted.

For No. 8 Wire—for each additional twist 20 lbs. will be allowed, but in no case will a less breaking weight for standard diameter than 1,020 lbs. be accepted.

For No. 11 Wire—for each additional twist 10 lbs. will be allowed, but in no case will a less breaking weight for standard diameter than 500 lbs. be accepted.

week, by a friend of mine, "What that fungus upon the wires was?" An improvement upon this process was that introduced by Messrs. Brooks, who serve the wire with a covering of prepared tape; samples of wire so prepared are now before you. But a process was introduced in America which really was very promising, and that was one by which the wire itself was protected with copper. A core of steel wire was taken, which was surrounded by a layer of copper, the whole being tinned together; and it was hoped that, by this process, the wire would become protected from the deleterious gases of the atmosphere. But it was unfortunate that the metals used were of varying expanding properties, and the result of the combination was that, after a little time, the copper covering cracked, moisture got inside, and attacked the inner metal, and very soon the whole arrangement was given up as unsatisfactory. Four hundred miles of wire prepared in this manner were sent to China, and although it was never put up, but remained in store, when it was overhauled, it was found to be quite unfit for the purpose intended. We put some up in South Wales, and it only lasted three years, and a very little experience very soon condemned the whole arrangement.

But another and more promising process has been introduced, also in America, by Messrs. Wallace Brothers, of Ansonia, Conn. In this process, a core of steel wire is taken and passed through a bath of sulphate of copper, which is under the operation of a very powerful current of electricity, and the result is, that the copper contained in the solution becomes deposited in a thick layer on the wire, and is homogeneously fixed around it, so that there is no joint to burst, or any crack to be made by expansion. This process is really very promising, and is now under actual trial. The great advantage of such a wire is that, while it gives us the advantage in point of resistance of No. 4, it is as light as No. 11, and as strong as No. 8. For long distances, such as carrying a wire 3,000 miles over the centre of Africa, such a wire would be invaluable; but we have not yet had sufficient experience of it to say that it has acquired a thoroughly practical form.

The accidents to which telegraph wires are subject are sometimes very curious. Of course there are many accidents to which all wires are liable—accidents along road and railway—but our great enemies are birds. In some parts of the country birds alight upon the wires in great flocks, and they all, by some curious instinct, fly off together, and set the wires vibrating, causing them to come into contact. This is especially the case at that time of the year when the migrating birds congregate prior to leaving our shores; and in the southern parts of England, in the Isle of Wight and neighbourhood, we are especially troubled by contacts put on by birds. I have had a case of a wire being absolutely broken by a goose flying against it. You would scarcely conceive it possible that a goose could have sufficient strength of wing to break a wire; but on the South-Western line there was a case where a No. 8 wire was broken by a goose flying against it. Of course, I need not say that the animal itself suffered considerably, as well as the wire. In India, the vultures have a curious habit of dropping the entrails of animals they devour upon the wires, and this is one great cause of interference to the working of the wires in that country. In England, on the Midland Railway, I have known of a snake being dropped on the wires, causing a fault which we call contact, and so disturbing our working.

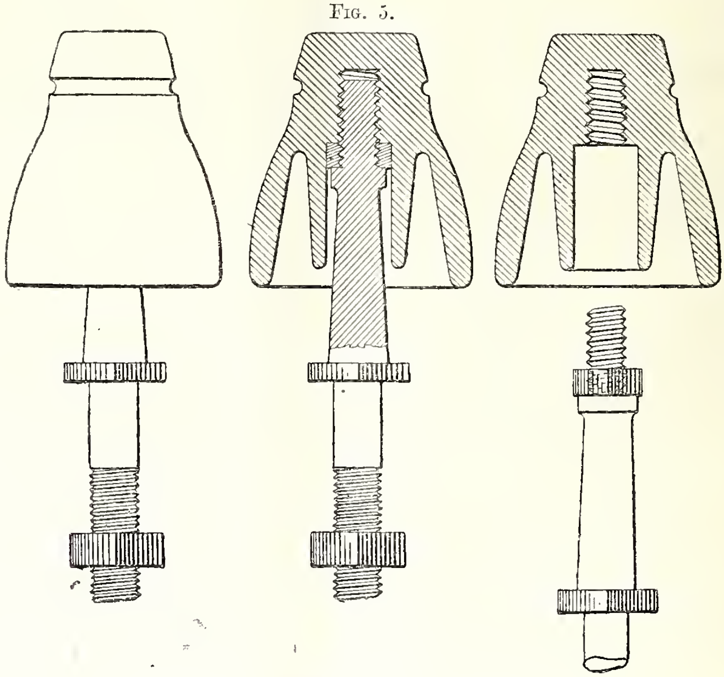
You will observe that the advance that has been made in the wire has been principally in its electrical conducting qualities. Its strength remains the same; its size remains the same; it has become cheaper than it used to be, from the greater de-

mand and less cost of production; but the care and thought that have been applied to the substance of the wire have been the means of improving its electrical capacity in the proportion I have mentioned, viz., nearly 50 per cent.

Now, as to that which supports the wire. Wires are suspended along the line from pole to pole, at distances of about 80 yards; and at every point where the wire rests against the pole (the pole itself being a conductor), if it were not protected in some way, the electricity passing through the wire would fly to the earth and disappear. I told you that on the first line, the insulator that was used was a goose-quill. This was speedily replaced by an ordinary earthenware ring; and from that day to this changes have been going on—from rings to cups of all kinds and forms, made of either earthenware, glass, white porcelain, black ebonite, or any other material that the genius of the inventor or manufacturer could bring forward. In this field we have been taught what to use solely by experience. From 1840 to the present day, everybody who has had anything to do with telegraphy has been devising some dodge by which the power of our insulators can be improved; and the concentration of experience of telegraph engineers all over the world has been to show that the best material is white porcelain. On the pole before you we have samples of the different kinds of insulators that are in use. The white porcelain one is used to a very large extent in this country. The two brown earthenware ones on the lower arm are also extensively used here; they were, I think, introduced by Mr. Varley about 1860.

Here is an iron capped white porcelain insulator which has been recently introduced by Messrs. Johnson and Phillips. It is peculiar in this way, that between the wire and the bolt the current would have to pass through a cup which is full of oil. Oil is a capital insulator, one of the very best insulators that we have. A current in escaping would have to pass through the oil, which offers something almost irresistible to its passage, and thus the insulator is an almost perfect one. But at the present moment the practical experience of its mechanical properties is not very satisfactory. It is still undergoing a trial, and cannot therefore be said yet to have been adopted. The use of insulators is a very important matter with us in the Post-office. For instance, from the figures of the past three years, the average annual number of insulators used by us has been 86,000. The kind that we are now adopting is the one you now see, Cordeaux's Screw Insulator (Fig. 5). Its principal merit is the considerable length of surface that a current of electricity has to flow over before it can escape through the bolt

Fig. 5.



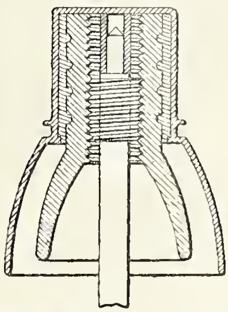
CORDEAUX'S SCREW INSULATOR

and pole to earth. There is the outside cup, and another cup inside, inasmuch as it has been found by experience that, to maintain the insulation of a line perfect, you must keep your supports clean. Any of you who are in the habit of making electrical experiments, must know how essential it is to wipe your supports, and keep your insulating points perfectly clean. And when you erect a line, as between London and Liverpool, and imagine that your insulators are going to keep clean for 100 miles or more, and always to remain the same, you make a very great mistake. The chief merit of this insulator is that it has the means of being readily removed. It unscrews, can be cleaned, and then simply screwed on to the bolt back again, and is as good as ever. So that, while the outer cup, from its large surface, has the power of insulating very fairly, the insulator

also has the great advantage of being readily cleaned.

The telegraph lines of the Post-office suffer tremendously from the breakage of insulators, caused by stone-throwing, and a large portion of the 86,000 I have just mentioned is absorbed in replacing damage in this respect. Insulators make the best cockshies in the world, and I do not know of anything more tempting to a fellow walking along a road full of stones than to take up one, and have a shy at one of these white insulators. The result is that many insulators are broken from stone-throwing. Lightning, again, undoubtedly breaks a great many insulators; perhaps, not so many in England as in other countries, but, nevertheless, we do suffer to a certain extent. Here (Fig. 6) is an iron-covered insulator that has been

Fig. 6.



OPPENHEIMER'S LIGHTNING GUARD INSULATOR.

recently introduced, which also is a lightning protector. It is protected with an iron cap, and the bolt screws in, so that it brings, opposite this iron cap, a point of the bolt that supports it. This bolt is prevented from touching the iron hood by an ebonite washer; when it is screwed into its place, a little cement is put in to make it absolutely tight, and there you have an insulator and lightning protector. It is one of the most recent inventions in this direction, and is the invention of Mr. Oppenheimer, of Manchester. This form of insulator has been sent out in large quantities to Australia, where they suffer very much from lightning, and I think it is very likely that it will be sent out to other countries where similar experience is felt.

To give you an idea how essential it is to protect lines with insulators from the escape of the current, I may mention this, that one of the severest tests that we have in this country to the efficient working of our lines is due to those storms that come up in the winter from the south-west.

We, unfortunately, live in a country which is said to have a climate, and a villainous climate it is. This curious country of ours is washed by the warm Gulf-stream. The warm Gulf-stream generates clouds of aqueous vapour. This aqueous vapour, when it comes in contact with the colder ground of our little island, is thrown down in the form of rain. But there are periods when immense clouds of this aqueous vapour pass over our island that do not produce rain, but they produce upon our insulators a thick coating of moisture, and there are one or two days in nearly every year when the air becomes, as it were, supersaturated with moisture, which, when it comes in contact with any substance (such as our wires) a little colder in temperature, deposits this moisture upon it in the form of water, that acts as a conductor and impedes working.

We try to get our insulators to offer a resistance to the passage of the current equivalent to 100,000 megohms each, and one megohm (or one million ohms) per mile is the standard to which we try to work. In very wet weather, it frequently comes down as low as 300,000m. per mile, but on the 22nd and 23rd of Nov., 1877, many of our lines skirting the sea-coast fell down as low as 20,000m. per mile. The result was that there was a practical breakdown throughout the whole country. The same thing took place on the 20th November last, between five and six o'clock in the evening. We could trace the vapour arising, as it were, in the South Wales district, somewhere in the neighbourhood of Bristol, and gradually proceeding on its way, as indicated by its influence upon our wires working from the central station, right across England towards the North. Fortuuately, this extremely marked effect only occurs at rare intervals, but there are two periods in the day at which a similar effect is experienced, though in a much milder form. Immediately before sunrise there is always a deposition of dew on our insulators, when our lines test very badly, and we have a recurrence of the effect immediately after sunset. These two periods are marked, unmistakeably, by the action on our wires. You see, in this particular branch of insulation, experience, again, has led us to various improvements, so that, compared with the goose-quill in the days of old, the insulator of the present day stands almost preeminent.

As regards the supports of these wires and insulators, experience has pointed out that, on lines of a small number, such as one or two wires, 16 poles to the mile are sufficient. On main lines carrying a number of wires, it is necessary sometimes to have as many as 24 poles per mile. In the early days the most expensive timber was used for these poles. The very best Memel timber that could be procured was utilised, and every pole cost a very large sum of money; but with experience wiser counsels prevailed, the expensive timber was found to be unnecessary, the common larch timber of this country was used, and continued to be used for many years. But it was found that plain timber, in this very moist climate of ours, very rapidly decayed. It invariably decays at what is called the "wind and water mark," that is, the ground line where the timber comes in contact with the earth. There is an alternate succession of moisture, heat, and cold at this point, and the result is the germination of vegetable and mineral growth, and gradual decay of the timber. To cure this, various processes were produced to try and preserve the timber. "Burnetising" consisted in saturating the timber with chloride of zinc; "kyanising" consisted in impregnating the timber with corrosive sublimate. In the "boucherising" process (taking its name, like the others, from the inventor) the pores of the wood were filled with sulphate of copper; and various other modes were applied, all of which proved inefficient except one. The successful process of preservation is that of "creosoting."

This process is adopted with every pole in the Postal telegraph service, and, I believe, with all poles on most of the railways. Creosote is antiseptic. It is something that will instantly kill any animal or vegetable germs in the timber, and it fills the pores of the wood with a waterproof material that keeps it practically dry. In fact, poles which were erected in 1848, on the Portsmouth line, are now as sound as the day when they were first put in; and if a pole be properly served with this creosote, it will, as far as we know at present, last for ever. On the other hand, of course, the proper application of this antiseptic process cannot always be relied on, and poles have decayed from its imperfect application.

There are countries where wood cannot well be obtained, so that these preserving qualities are inapplicable, and where iron is used. In some countries iron is used to a very large extent. Through the kindness of Messrs. Latimer Clark, Muirhead, and Co., I have here a complete iron pole, many thousands of which have been sent to South Africa, South America, and various of our colonies. It is a very light and pretty pole. It has a cast-iron base, and a wrought-iron cone at the top; and you can see how the insulators are fixed on brackets attached to it. On our wooden poles the insulators are fixed by means of wooden arms. Messrs. Siemens, whose name is a household word among telegraph engineers, have also some very light and elegant iron poles, not at all unlike the one on my left, but which are, perhaps, used at the present moment more than any other kind. Mr. Norman, of the firm of Tyers and Norman, has introduced on the Furness Railway a specimen of iron pole made of what is known as angle iron, and which is said to be very effective. But, comparing an iron pole with a wooden one, it is found that a creosoted Norway pine pole is cheaper, more efficient, and more durable, I believe, even than iron. I do not, personally, believe much in iron for telegraphic poles.

Now, there are many practices applied to poles which are useful and beneficial. For instance, suppose two wires were affixed to the two insulators, one at either end of the arm at the top of this pole, and that wet weather set in, and coated each insulator and soaked the arm with moisture. Water being a conductor, this moisture would allow of the current on the one wire to pass down the bolt to the arm, where it could either go down the pole to the earth, or pass along the other half of the arm to the other wire, and produce on that wire what is called a "weather contact." In the early days it was quite impossible to work one wire without producing upon a neighbouring wire, in wet weather, this "weather contact." To remedy this, a very simple process was introduced, which was to put all the bolts of the arms directly in contact with the earth, by means of a wire carried down the pole, and so forming a passage by means of which the current escaping from one wire went direct to earth without interfering with another wire at all. This process was found out by pure accident. In the early days, it was thought necessary to fit every pole with lightning protectors, to prevent their being shattered by lightning. Lightning does play havoc with our poles sometimes, but not to a very large extent; and it was found that, where the poles had been provided with these lightning protectors, the "weather contact" did not appear. Here is a sample of the very earliest kinds of arms used. You will see that they are fixed crosswise, or in the shape of a letter X, with a bolt through the cross, which bolt was connected with the earth by a wire, to prevent weather contact. These arms were erected about 1850, by the British Telegraph Company. You will notice that the insulators, which were white porcelain when put up, cannot be said to have retained their colour. They have become coated with a soot-coloured dirt, which has eaten into the porcelain, and cannot be rubbed off.

Now, having erected the wires upon the poles, we must have some simple way of "leading," or bringing them into the offices. We have a specially strong insulator at the terminal pole, to which the line wire is connected, and it is from this insulator that the gutta-percha covered leading in copper wire is attached to the line wire, and passed through the insulator into the pole, whence it is carried into the ground, and so on into the office. The insulator contains an inner cup, filled with oil, which prevents the current escaping. This form of insulator for leading-in purposes (of which a specimen is on the table) is of recent introduction, is now under trial, and there is every probability of its proving valuable. The old plan of leading-in was simply to attach the end of the gutta-percha covered copper wire to the iron line wire, and to carry it direct to the pole, leaving the gutta-percha exposed to the air, causing it to speedily crack and become defective.

Among the accidents to which open telegraph lines are liable, we must enumerate snow-storms. Snow-storms appear periodically. When I say snow-storms, I speak of telegraphic snow-storms. Snow-storms we have frequently; but telegraphic snow-storms, I am happy to say, are very rare. The telegraphic snow-storm is always accompanied by frost and wind. The snow falls, and as it touches the wire it freezes, and adheres to it, forming a layer; another layer falls, and is frozen upon the first, and this process goes on till the wire becomes, say, as thick as my arm; and when this happens, and is succeeded by a gale of wind, the surface exposed to the wind is so great, that it is impossible for the strain to be borne, and it is simply a question of which shall give way first, the pole or the wire; one must go, and the result is that the wire, as a rule, gives way. It fortunately happens that, during the 40 years that telegraphs have existed in this country, there have been only two snow-storms of this description. The one took place in the year 1866, and the other in 1877. Again, it is fortunate that, when these storms occur, they are confined to a small section of the country, and so the damage suffered from them is limited, as regards the area of the storm, but within that area the havoc done is very serious. For instance, the storm of 1877 swept the country in a broad band, from the Bristol Channel to the Wash; and along that broad band, of about 30 or 40 miles, everything was swept away as though the destroying angel had passed over the country smiting everything down. This has only happened twice, but, nevertheless, it may occur again, and to avert the damage, it has been considered, at times, whether we ought not to put

some of our wires underground. There has been a great cry, particularly in the public papers, about this method of erecting our wires, and suggestions made that they should go underground.

We have a great many wires in this country that go underground. The telegraphs in this country consist of—

Miles.			Miles.				
11,055	of poles	and	30,921	of	wire	upon	roads
12,952	,,	,,	58,127		,,	,,	railways
432	,,	,,	4,123		,,	,,	canals
445¾	,,	line	9,023		,,	,,	underground

making a total of 24,885 miles of line, and 102,194 miles of wire in the country.

The figures have not been brought up to date, and it may, perhaps, be roughly taken that there are nearly 10,000 miles of wire underground. But to put wires underground is a very costly operation. It costs a great deal more to put them under than overground; but besides this, there is another very great objection to underground lines of any great length, and that is that when you put wires underground you retard the rate at which they work, and diminish the capacity of the wire for the transaction of business, and so reduce its commercial value. Suppose, for instance, we were to erect an underground line from London to Liverpool. It would cost, perhaps, four or five times as much as an open line, but it would, in addition to that, diminish the capacity of the wires laid down in the same ratio. Such a line would not be able to transact, perhaps, one-fourth of the business that an overground line between the same points would carry. So that, assuming the underground line to cost four times an overground line, while at the same time having only one-fourth its carrying capacity, the commercial value of the underground would be one-eighth of that of the overground line.

In England, we confine our underground lines chiefly to the neighbourhood of towns. In going through towns with a telegraph line, we have the choice of carrying the wires overhouse, or of placing them in pipes through the streets. We prefer the latter, because the lengths of underground being short, their retarding effect upon the wires is only felt to a very small extent, and it is owing to this fact that the overhead lines in London, which previously disfigured the town, are fast disappearing, and will, before long, have almost entirely disappeared.

When we come to underground lines, we depart from the use of iron wire for our conductor, and use copper wire. There the causes which render copper wire inefficient for open air lines cease, and we introduce copper, coated either with india-rubber or gutta-percha. Here, perhaps, as great an improvement has been made as has been made in iron, perhaps greater. When the Atlantic cable of 1858 was made, it struck Sir William Thomson that the results were worse than he expected, and he was led to examine the quality of the copper, and he found that it only gave 40 per cent. of the necessary standard. This caused the quality of the copper used for submarine and underground telegraphs to be carefully examined, and, step by step, has brought about the result that, when the Persian Gulf cable was made in about 1860, it was specified that the core should be made of 76 per cent. of pure copper. The quality really supplied was 89 per cent., which proved that the manufacturers had been fully alive to the necessity, and had surmounted the difficulty.

The specifications of the Post-office provide that the copper shall contain 94 per cent. of pure copper, and it very often happens that 98 per cent. is given. So that, since the Atlantic cable was laid in 1858, it is easy to see how very great an improvement has been made in the quality of the copper conductor used, greater, in fact, than the improvement which I mentioned as having taken place in the iron wire.

Copper wire, like the iron, is used of various forms and in various stages. It is generally covered with gutta-percha. Gutta-percha is the gum of a tree that is found in Borneo and the islands of the Archipelago, and it comes to this country in the crude condition of this mass which is before you. The copper wire is drawn through this gutta-percha, when in a plastic state, and is then passed through dies, which regulate the size and shape of the covering, as you see.

The specimen before you is of the kind which is used generally for our underground lines. The weight of the copper is, I think, about 39 lbs. per statute mile, and that of the gutta-percha about 46 lbs. per statute mile.

Where we come to the use of this wire for cables, various other preparations are used, and the speed at which a cable can be worked really depends upon the thickness of the copper, and the thickness of the gutta-percha.

Curiously enough, gutta-percha owes its introduction to a lecture delivered in this very room.

In 1845, a Dr. Montgomery exhibited a specimen of this crude stuff, which he had brought from Calcutta, where it had been imported and used for various purposes. It so happened that, among the audience sat Dr. Siemens, who thought that there was something in this gutta-percha. He obtained some of it, sent it over to his brother in Germany, Werner Siemens, in 1846, and, after some experiments, they found that it was a splendid insulator. It was applied as a coating to wires, and, in 1848, a great many miles of wire so coated were made and laid down in Germany. Germany is, in fact, the birthplace of gutta-percha covered lines, and the first idea of the use of this article for such purposes was obtained from a lecture delivered in this room.

In 1851, the Electric Telegraph Company constructed a main trunk line of gutta-percha covered wire from London to Liverpool and Manchester, consisting of eight wires, laid in pipes buried about 2 ft. in the ground. In those days, the method of making joints was unknown (really, one blushes now to think of the many mistakes that were made), and the result was that this underground line proved a desperate failure. It lasted only three or four years, was taken up, and from that day to this we have not done very much in this direction, for the reasons I have stated. But between Liverpool and Manchester, an underground line has been constructed with all our present experience, and with the knowledge of the failures made in the past, and it has proved, up to the present time, to have been very successful. But, notwithstanding this, as I told you, I do not think it is at

all likely that we shall extend operations in this direction very much.

I have, on the table, specimens of underground work laid in Germany. In England it is our practice to draw these wires into earthenware or iron pipes, but in Germany they have taken their idea from a submarine cable (to which I shall refer presently), and there they take seven gutta-percha wires, form them into a strand, or rope, protect that rope with iron wires outside, and cover the whole with a bituminous compound, and lay it, just as it is, in the ground. Where rivers are crossed, exactly the same cable is used, but a thicker outside coating of iron wires is used to give it strength. There are many hundreds of miles of such cable now laid in Germany, and, in fact, all the principal towns there are connected by means of these cables, buried, I think, a little more than a mètre deep.

In England we adopt a different plan, and draw the wires into pipes, and in the streets of London we have pipes laid such as you see here. This is the principal kind we use. It is three inches in diameter, and will contain 70 or 80 wires. The section before you contains a number of wires which have been drawn in. The pipes are laid down, an iron wire is threadod through them, and as that iron wire is drawn out, so it draws in the gutta-percha wires that are cabled up as you see there.

Gutta-percha wires would be very well if they would last. But, unfortunately, gutta-percha is a gum that only appears to last when in water. In water it apparently is indestructible. Cables that were laid in 1851, that have been brought up within a recent date, are now as good as the day when first put down. But when gutta-percha becomes exposed to the air, to the alterations that our climate and other climates suffer, especially when exposed to the action of the sun it decays very rapidly; it oxidises, and becomes a kind of resin that can be easily crumbled into a snuff-like substance. Many attempts have been made to protect the percha, and to arrest this rapid decay. It has been surrounded by tape soaked with tar. Tar itself has been found to be injurious, and has been supplanted by other materials, but at the present moment we have not yet succeeded in finding anything that renders gutta-percha indestructible. In fact, when exposed to air, as when suspended in tunnels, it seems to have a life of about 10 years; when laid down in our iron pipes, under the influence of the variations of temperature and moisture that exist there, it seems to last about 20 years; but in the sea, where it is exposed to equable temperature and equal conditions, it apparently seems capable of lasting for ever.

There are many curious accidents and causes of interruption to working that we meet with in our gutta-percha covered wires, and one of the strangest is one of the last that we have discovered. We have found in many places that this gutta-percha is apparently gradually eaten away. It seems to go not unlike the way in which open-air wires rust away; and this curious action only occurs in certain places. In certain parts of the country, North Wales, Dublin, Kent, and in one part and another, we have found this curious action going on; and careful examination and inspection under the microscope have led us unmistakeably to conclude that it is due to something or other eating away the gutta percha. Curiously enough, wherever we have detected this action taking place, there also we have found swarms of a very minute insect, a very little thing, belonging to what is called the spring tail tribe. It is a little white fellow that you can scarcely see, and who, by the way, when you do see him, seems conscious of the fact, for he immediately disappears with a spring. It is the *Templetonia crystallina.* It abounds in swarms in certain soils, and seems to have a great liking for gutta-percha. It does not remain near the wire when it has eaten its way through, but, apparently, immediately retires when it touches the wire, as though it had received a shock, and makes a sudden retreat. It is a very curious fact, and until recently it was unknown, that any living creature had a taste for gutta-percha. There are a great many specimens of gutta-percha on the table that have suffered from the attacks of this little insect, which, no doubt, you will look at with interest. There are, also, specimens of gutta-percha wires that have been mauled by rats, who, from their mischievous habits, often cause us great trouble. We have had gutta-percha wires damaged by field-mice, and even by rabbits. I had a specimen, damaged by mice, which, most unfortunately, got lost in the post. There were absolute indications of their little teeth on the copper wire itself.

Again, there is a fungus which damages gutta-percha, this generally happens in the neighbourhood of oak trees. But we have got another animal called man that sometimes also disturbs gutta-percha, and in Hull, not very long ago, all our wires on one particular route were broken down, and it was found that a man, in laying down a drain, had deliberately cut the wires, and when he was remonstrated with he said "but I put them back again." He made two great cuts through the percha and put the wires back again, leaving it very difficult for us to find the place.

Sometimes through towns our wires are carried overhead. In that case the wires are frequently made up into cables, and india-rubber is then used for the purpose. Here are some blocks of crude india-rubber showing the way in which it is imported into this country. There are several blocks of different qualities, but the best quality we obtain from Para. Here is a wire that has been coated with india-rubber, intended principally for torpedo cables. Where india-rubber is used for overhead purposes, the wires coated with it are made up into cables according to the specimens before you, of various numbers, ranging to as many as 50 in one cable. The wires are very finely covered with a thin coating of india-rubber, and when cabled up are suspended from pole to pole overhead along the streets. Such cables are used very largely for private wire purposes, in working an instrument which I shall have the pleasure of showing you next meeting, I mean the Wheatstone A B C instrument. But it is when we come to consider submarine cables that gutta-percha and india-rubber become of immense consequence. There a cable has not only to pass a deep and long sea, but it has to brave various contingencies, and besides being requisite that it should be of proper capacity to carry currents for its distance through the water, it should also havo strength to enable it

to fall to the bottom of the sea, and also to have sufficient strength to permit of it being hauled up again in case of failure, and in case of repairs being required.

Submarine cables are really practically of only one type. The first cable was that laid down in 1851. A cable, in the principles of its construction, is nearly the same everywhere. You, first of all, have copper wire, which is your conductor, and which conveys the currents which operate your instruments. This copper wire is surrounded by a coating of gutta-percha, such as you see. It is then coated with a layer of hemp well saturated with tar, sometimes with tar water, and then, to give it strength, the whole is surrounded by a strand of stout iron wires. So that there you have conductor, insulator, serving, and outside wires, and all cables really follow this type. Here, for instance, is a river cable, strong and heavy, intended for a river where ships drag their anchors, and where strength is of consequence. In the glass case on the table you will find specimens of all the different forms of Atlantic cables, and the collection is well worth your examination. There is a specimen of the Atlantic cable of 1865 and of 1866, with their shore ends. There is a piece of the 1865 cable which was brought up from a depth of 2,000 fathoms.

There is a piece also of the grappling rope itself which brought that cable up, and you will also find in the case a model of the grapnels used to bring the first Atlantic cable up to the surface in 1866.

Here are specimens of the cable which is about to be laid down from Aden to the Cape of Good Hope. There are three specimens, one being that of the portion used for the deep-sea section, the second of the first shore-end section, and the third being provided with a still stronger outside covering for the shore-end proper. The deep-sea portion is much thinner than either of the other portions, but it is sufficiently strong to bear five or six times its own weight in water. It has sufficient specific gravity to descend with the requisite velocity to the bottom, and, when there, it has all the properties requisite to make it durable for a great many years. But no cable has yet been immersed, or even devised, which can be said to be perfectly durable. The form of the Atlantic cable of 1865 and 1866, which is similar to that of many other cables, was deficient, inasmuch as, while it possessed sufficient strength to enable it to be submerged, it had not sufficient durability to retain that strength to enable it to be brought to the surface again. And when the cable failed, the repairing ships sent out were utterly unable to bring it to the surface in a sufficient length to enable them to effect repairs.

Here are also some interesting specimens of the direct United States cable. The cables of 1865 were made by the Telegraph Construction and Maintenance Company, but the direct United States cable was made by Messrs. Siemens. The difference between the two is very slight indeed. There is a little difference in the form of conductor, but the principle of the two will be found identical.

The deep sea portion of the Cape cable, while it differs to a certain extent from the Atlantic types, is still deficient in that absolute durability which all cables ought to have. In fact, there is room for invention in this direction. Generally, one notices that, where there is a want, someone will spring up with an invention to meet that want. Here is a want that has existed for many years, but no one has invented a cable which can be said to be perfectly adapted for its purposes; so that, if anyone here is of an inventive turn, let me recommend him to try his hand at inventing a cable which will give us all the requirements needed.

This cable to the Cape has one peculiarity in which it differs from any others. Now, among the various accidents to which cables are subject, there is one due to the existence of life at the bottom of the sea. We know that in different seas there are certain little insects, sometimes *Teredos*, sometimes *Xylophaga*, sometimes *Limnoria*, and others of very hard names, which have a peculiar liking for gutta-percha. These little *Teredos* attack us on sea as well as on land, and the trouble they cause us is sometimes immense. We suffer from them very much on the Irish coast, where the little wretches have found their way to the gutta-percha, and have there scored and figured it in a very curious way, samples of which you will see on the table.

To put a check to their boring instinct, the Telegraph Construction and Maintenance Company, who made the cable which is being laid to the Cape, but which was originally intended for Australia, have surrounded the gutta-percha with a wrapping of brass; and if any of these boring insects abound in any portion of the line where this brass wrapping is used, I have no doubt that the brass will be too much for them, and that they will find themselves terribly beaten in making any attempts to get at the gutta-percha.

It is found that these little animals do not exist at greater depths than 100 fathoms, and, therefore, in the deep sea portion of this cable, the brass wrapping will not be found.

There are a great many accidents to which submarine cables are subject. One of the principal is that of a ship's anchor, and it was the disturbing element of a ship's anchor that prevented me from having the pleasure of being before you last Monday. On the table is a piece of cable which has been taken out of that crossing the River Humber. The cable which crosses this river is one of the most important that we possess, and for that reason one of the strongest kind of cable ever made was laid down. In the Postal Telegraph Department we have no less than 62 cables, and their aggregate length of 1,224 miles contains a total of 3,809 miles of wire. To cross rapid streams and important rivers, strong cables are used, and to cross the Humber, which during spring tides runs at the rate of six to seven knots an hour, a cable of the strongest type was used; yet it had not been down six weeks when a ship got hold of it, and the cable was caught by its anchor. The heavily-laden schooner riding on a strong tide, with its anchor attached to the cable, brought to bear an enormous force, and, perhaps owing to the construction of the cable, this force would not be equally divided among the outside protecting wires, and thus one wire, bearing the greater strain, gave way, followed by the snapping

of a second, and so on till the whole cable was severed in the straggling and tangled manner that you see, which is very different from its symmetrical form when first laid. This break occurred in a very nasty stream, where the cable was so buried in mud that I could not find it; and I was despairing of being able to give even a second lecture here, when a happy thought occurred to me. I had spent a whole day in grappling after this cable, trying over and over again, and yet never getting near it, when it suddenly came into my mind that Shakespeare makes Bassanio say "In my school days, when I had lost one shaft, I shot his fellow of the self-same flight, the self-same way, with more advised watch, to find the other forth; and, by adventuring both, I oft found both." So, knowing that a ship had dropped its anchor over the cable, I thought we would drop our anchor too, and we did, and waited a whole tide, and when we hauled the anchor up there was the cable.

The chief cause of accidents to cables, next to that of anchors, is probably due to the abrasion of cables on rocky bottoms. The bottom of the sea is frequently of an undulatory nature, and the cable remains suspended from point to point, and at such points the wire becomes chafed and worn away, and speedily decays. I am sorry to see that the time at my disposal has gone so rapidly, that I cannot particularise to you many of the different causes that lead to the destruction of cables, not only abrasion, not only accidents in paying out, but accidents that exist afterwards; for instance a whale once caught a cable in the Persian Gulf and broke it; a shark's tooth has been found embedded in a cable, and a sinking ship has caused damage to a cable.

Sometimes, the cables rest on corrosive stones, copper ores, and ironstone, when corrosion sets in, and causes the cable to speedily fail. Volcanic action sometimes damages cables, as also rock slips. In the Bay of Biscay, which is crossed by the Direct Spanish Company's cable, there is no doubt that such a cause has interfered with the cable on two occasions; curiously enough, interrupting the wire each time on the same day of the year. There is a peculiar shelving of the rock, and slips exactly equivalent to our landslips take place at intervals.

Icebergs, too, from the North Atlantic, frequently carry large pieces of rock, which fall to the bottom when the iceberg thaws, and, in their descent, are liable to fall across a cable and damage it.

There are also faults due to imperfect joints, due to accidents that pass inspection during the process of manufacture, but which slowly develop themselves after submersion or lapse of time.

Lightning, earth currents, and things of that kind affect cables, but, nevertheless, the eye of the telegraph engineer is constantly watching these circumstances as they happen, and he tries to bring to bear upon them all the power and thought he possesses; and the result is that, by slow experience, the cable of the present day is very superior to that used in the early days, and the improvement has been equal to the advance, which I hope I have been able to show you, has been made as regards the insulators and iron wire.

CORRESPONDENCE.

VENTILATION OF SEWERS.

It is long since I have read such an excellent practical letter upon any sanitary subject as that of the Medical Officer of Health for Halifax, in the Society's *Journal* of the 3rd inst., and, thoroughly agreeing with him as to the danger of relying upon any of the numerous traps and cowls as a defence for our houses against sewer gas, I should like, with your permission, to carry the argument one step further.

Mr. Ainley proposes to destroy the sewer gas by passing it through the furnaces of manufactories, but I think that he will agree with me that if we had self-cleansing sewers protected from rain-water and road detritus, we might very materially reduce (if not altogether prevent) the formation of the gas, which emanates, not from fresh moving sewage, but from the stagnant, putrid ponds of filth which too often exist in the flatter portions of our town sewers in dry weather.

These large conduits, running half full during heavy rain, may at such a time be self-cleansing, but otherwise they are generally self-fouling gas generators; whereas a small pipe, duly proportioned for the removal of the sewage proper, would be always self-cleansing, and could be readily flushed; while, at the same time, Mr. Ainley's furnace ventilation could be more effectually employed than under the common system.

Alfred S. Jones, Lieut.-Col., Assoc. Inst. C.E.
Hafod-y-Wern Farm, Wrexham,

THE INTERNATIONAL ASSOCIATION FOR THE IMPROVEMENT OF THE WATER SUPPLIES OF POPULATIONS.

It appears to me to be due to state my belief that the movement on the Continent, by the International Association for the Improvement of the Supplies of Water for Populations, has been owing to the attention given to the subject in this country by his Royal Highness, our President. Evils similar to those experienced here in periods of drought, I need scarcely say, have pressed on populations on the Continent; and the proceedings of our International Association for the direction of attention to measures of prevention, have received the authorisation of Prince Bismarck for Germany, and of the public authorities for France, and will, I have no doubt, receive the requisite authorisations and countenance from other Governments, and be actively promoted by the delegates from the different nationalities who attended our Congress.

Edwin Chadwick.

POSTING PROOFS.

I think it is due to the readers of the *Journal* to remove an impression, which has spread abroad, that the farthing stamp is to be affixed to the posting-proof forms, like the penny postage-stamps. The *Times*, in a leading article of the 9th, gave a most explicit comprehension of the system, and your own *Journal* has on two occasions fully descanted on the subject; misconception has, however, arisen, and I therefore ask permission to state that the farthing proper would not be required, neither would it be necessary for the Government to lay in a large stock of the smallest coin of the realm to meet the demand for change. Each leaf is impressed with the stamp conveniently embossed on the paper, of which it forms part, and the smallest number allowed to be sold at one time would cost one penny, without reference to the even numbers contained in the larger stitched packets.

A. Clifford Eskell.

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,405. Vol. XXVII.

FRIDAY, OCTOBER 24, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

PARIS EXHIBITION.—ARTISAN REPORTS.

The selected Reports on the Paris Exhibition, made by the artisans who were sent out last year by the Society of Arts, have now been published by Messrs. Sampson Low and Co. The following is a complete list of the Reports, with the authors' names:—

Pottery. Frank Harris.
Pottery and Earthenware. Aaron Grecu.
Pottery and Porcelain. Charles Toft.
China Painting. J. Randall.
Terra Cotta. George Bedford.
Table and Fancy Glass. Joseph Leicester.
Stained and Painted Glass. Francis Kirchhoff.
Ornamental Ironwork. William Letheren.
Carved Woodwork. Mark Rogers, jun.
Wood Carving. William H. Howard.
Stone Carving. Henry Turner.
Machine Tools. David Walker.
Mechanical Engineering. J. W. Phillips.
Mechanical Engineering. James Hopps.
Mechanical Engineering. John Ives.
Agricultural Implements and Machines. J. B. Grant.
Horticulture. J. Simpson.
Flower and Ornamental Gardening. George Stauton.
Bricklaying. George M. Berry.
Stone and Machinery used in Stone Work. William Pyle.
Plaster Work. M. Curley.
Cement-crushing Machinery. E. E. Whitehead.
Joinery. William Hodgson.
Furniture. Thomas Paterson.
Cabinet-work. Henry R. Paul.
Cabinet-making. John Fraser.
Watch and Clock-making. Henry Ganney.
Clocks and Watches. B. W. Warwick.
Jewelry. Edward Kirchoff.
Optical Instruments. M. Lambert.
Printing. William Bright.
Printing Machinery. Peter Lowson.
Machinery for Spinning and for Manufacturing Woollen and Cotton Fabrics. John J. Heywood.
Manufacture of Poplins. William Sullivan.
Saddlery and Harness. J. Hancock.
Shoemaking. John W. Smith.
Caoutchouc. Thomas Conolly.
Mining Products and Apparatus. C. Beringer.
Iron and Steel Manufacture. James Logan.

The price of the volume is 7s. 6d. Members of the Society of Arts, and Exhibitors at the Paris Exhibition, will be charged 5s. 8d.

Besides being published in a single volume, the reports have been issued in 11 divisions, making 12 parts in all, viz.:—

1. { Pottery and Glass. Part I. (4 reports.)
   { Pottery and Glass. Part II. (2 reports.)
2. Art Workmanship. (5 reports.)
3. Mechanical Engineering. (4 reports.)
4. Agriculture and Horticulture. (3 reports.)
5. Building Trades. (5 reports.)
6. Cabinet Work. (3 reports.)
7. Watch and Clock-making, Jewellery, and Optical Instruments. (4 reports.)
8. Printing. (2 reports.)
9. Textile Fabrics. (2 reports.)
10. Leather and India-rubber. (3 reports.)
11. Mining and Metallurgy. (2 reports.)

In the hope that these parts may prove acceptable and serviceable to the classes interested in each particular industry, they have been issued at the price of 6d. each. Twelve copies of any of the parts will be supplied at 4s. 6d.

The reports prepared by the artisans from Liverpool (10), Huddersfield (5), Bristol (9), Leeds (6), and Leicester (3), have been printed by the authorities of the various towns. It has not yet been determined whether the Dublin and Edinburgh reports are to be similarly printed, but the question is at present under consideration. The five reports by the Coachmakers' Company's reporters have also been printed, with an additional report on the same subject, at the expense of Mr. C. Saunderson.

SCHOOL BOARD DRILL.

The annual drill competition of the London Board schools, for the challenge banner presented by the Society of Arts, took place on Saturday afternoon, the 11th inst., in the grounds of the Lambeth Palace. At the last inspection in 1877, when all the schools were represented, there were 10,000 boys present, but last year there was no public exhibition of the kind. On the present occasion a selection had been made, consisting of forty boys each, from the following schools:—Thomas-street, Limehouse; Penrose-street, Walworth; Kender-street, Hatcham; Bloomfield-road, Plumstead; South Lambeth-road; Saint Paul's-road, Bow-common; Mantua-street, Battersea; Waterloo-street, Hammersmith; London-fields, Hackney; Olga-street, Bethnal-green. The proceedings commenced with a march past the "saluting post"—where the banner occupied a prominent position—in open column of companies, and after various evolutions, performed with considerable steadiness by all concerned, the banner was presented by the Hon. Lyulph Stanley to the Limehouse School. The next company in order of merit was that consisting of the boys of the London-fields School. Several members of the School Board were present, and a large attendance of visitors. Messrs. E. Chadwick, C.B., and Hyde Clarke represented the Council of the Society.

CANTOR LECTURES.

RECENT ADVANCES IN TELEGRAPHY.

By W. H. Preece,

Electrician to the General Post-office.

Lecture III.—Delivered May 5.

We have dealt with the nature of electricity, we have seen how it is produced, and how it is transferred from one place to another. We learned, in the first lecture, what that which is called an electrical signal is, and now we have to show how such electric signals are utilised for the reproduction of speech.

The art of telegraphy is, as was explained to you, simply the mode of transmitting to distant places the elements of language and the numerals. The elements of language are, of course, the simple A B C, and all that we have to do is—by the aid of this power, electricity—to produce symbols representing the letters of the alphabet at distant places. Now, clearly, if we can reproduce the letters of the alphabet themselves, we reduce telegraphy to its greatest simplicity. One of the earliest forms of telegraph introduced into this country was that by Wheatstone, which enabled us to read by the production or indication of the simple letters of the alphabet. Wheatstone's A B C apparatus was originally introduced in the year 1840, and was really upon a somewhat similar principle to that designed by Ronalds as far back as 1816. In Ronalds' telegraph, a disc, upon which the letters of the alphabet were printed, was caused to rotate, and the letters were indicated by mere pith-balls repelling each other at a given moment. In Wheatstone's apparatus, the letters of the alphabet are printed around a dial, and in front of that dial there is a small pointer which moves around the circle. We have here a specimen of the improved apparatus brought out by Wheatstone in the year 1858. It is what is known as the A B C apparatus. As far as mechanical construction and ingenuity are concerned, this instrument compares most favourably with any other kind, and to the perfection of its mechanical details, beauty of workmanship, and efficiency, we are entirely indebted to that mechanical genius, Mr. Stroh. Mr. Stroh's telegraphic apparatus will be shown to you in various forms, but here we have one of his earliest and finest specimens of workmanship.

Here we have a disc, or dial, on which the letters of the alphabet are printed, and in front of that dial moves a pointer, which is propelled by the current. The current itself is produced inside the box underneath the dial, by what is known as magneto-electricity. The production of electricity by the Gramme machine was referred to in the first lecture, and I will now only say that, whenever I turn this handle round, I produce for every revolution four distinct currents of electricity. These currents move the pointer or indicator over four letters. So that, when I press a key down, for instance O, I send just the number of currents that there are from A to O. Each current propels the pointer one letter, and when it comes to O no further currents go to the line, and so the letter O is indicated; and in this way I spell out the letters P R E E C E, and can read off my own name. This apparatus, as you see, is so simple in its mode of working that it can be placed in the hands of any old woman or little child, and its simplicity enables it to be used to a very large extent in the postal telegraph system. At many places, the post-office is kept by a small village grocer or haberdasher, who could not be expected to manipulate an instrument that required any amount of skill. This kind of instrument is also used to an enormous extent for private wire purposes. There are many merchants and professional men who have communication by this means between their house and offices, between various branches of their business, and between their hall and their stables. As an illustration of the ease with which this apparatus can be learned, I remember, on one occasion, that a telegraph-office was about to be opened in a small village in the Isle of Wight. An inspector was sent down to instruct the aged people who conducted the postal work, but, when he arrived, he found that the said couple had already opened the office, and had been taking messages for several days; and the old lady, with spectacles on nose, said that she had not had the least difficulty in understanding the apparatus. She learned it in half an hour, and sent the first public message within an hour after the instrument was fixed. This principle is utilised in nearly every country. In Germany, Messrs. Siemens have introduced an instrument like the one I now have here. It is based on the same principle as Wheatstone's A B C. There is a handle, which turns round and produces the magneto-electric currents. The circumference of the disc is divided into letters, and, as the handle traverses over the disc, currents are produced, and letters are sent by dropping the bar of the handle into a slot opposite each letter. In France, Breguet has produced a somewhat similar instrument; and, in fact, the principle has been adopted in most countries, except America. It is very remarkable that, in that country of invention, no dial instrument of this kind, so far as I am aware, has been introduced; and this is one secret why the telephone has been so warmly received in that country. No simple telegraph, that you could put in the hand of a child or any telegraphically-uneducated person, existed, and so, when the telephone was brought into existence, the Americans seized upon it with avidity. But in England this A B C instrument is very useful, and at the end of March 31st, 1878, a total of 4,641 of these instruments were in use in the United Kingdom, and I have no doubt that at the present moment the figure has reached 5,000. On the tables is one of the original instruments of 1858; and here is one of the latest pattern. The two are intended to be shown together, as, although they are similar in appearance, there is a wonderful difference in their mechanical details, and there is scarcely a single movement in the old instrument that in the new one has not been improved upon by experience, and now the instrument is really everything that one could wish. Of course there are defects inherent to the apparatus, but there are other defects which are not due to the instrument. For instance, at one of the very largest commercial houses in London that occupies a great number of houses, not 100 miles away from Westbourne-grove, where an A B C instrument exists, the instrument was reported to have failed. On an officer of the department arriving it

was found that the failure was due to the currents passing through the clerk working the instrument whilst standing on a newly washed floor. To mend matters he had put an iron plate on the floor to stand upon, and the result was to make confusion worse confounded. But when the clerk was made to stand upon a waste-paper basket the circuit was found to work thoroughly. Again, by constant turning of the handle, the journal upon which the pivot works is sometimes found to bind, and on one occasion on a circuit failing from such cause, an explanation was given that the "failure was due to the growth of the magnet." I need not tell you that magnets do not grow. Knowledge grows, and perhaps the knowledge of the individual who sent in such a report increased on that occasion. This A B C instrument is used where business is small, and where technical skill is not required. But there are stations where business is heavier, and where a little technical knowledge becomes necessary, and there is then adapted what is known as the single needle system. The needle system was first introduced by Cooke and Wheatstone in 1837, and consisted of five needles forming a single instrument. The five needles were made to indicate certain letters by their combined motion to the right or left. It was speedily found that the same result could be brought about by four needles, and owing to the difficulty of keeping wires always working, it was accidently found by those who were working an instrument on the Blackwall Railway, that an alphabet could be formed by using two needles only, and this led to the introduction of the double needle instrument. Again, it was soon afterwards found that one needle only was sufficient to enable an alphabet to be sent, and so the single needle instrument was adapted, and has remained in practical use in the country for many years. The letters of the alphabet are represented by beats of the needle, which has two movements, one to the right and the other to the left. A movement to the left and a movement to the right form the letter A. A movement to the right and three to the left form the letter B; right, left, right, left, C; once to the right and twice to the left, D; once to the left, E; and so on through the alphabet the letters are formed by combinations of beats to the right and left.

[The words, "Society of Arts" were now sent on a single needle instrument, first slowly and then rapidly.]

This instrument can be worked by an expert operator at the rate of 30, 35, or even 40 words a minute. Of all telegraph instruments, this is perhaps the simplest in construction. It merely consists of a couple of pedals which reverse the direction of the current, and a galvanometer (such as described to you in the first lecture), the needle of which is deflected to the right or left (according to the pedal depressed), and the limit of deflection is restricted by two small ivory pins. The instrument is learnt in a very short time by boys and girls, and where business is too great for the A B C, it is brought into use. It is almost universally employed by railway companies at their stations. The enormous advantage of this instrument is that it never requires adjustment or attention. It may be left untouched for 12 months, and, at the end of that time, will be found in good working order, and a message could be sent without any preliminary putting right. There is no other kind of instrument that will do this, and it is most remarkable that such an instrument has not found the same favour in other countries as it has in England. In the Postal Telegraph Department we have 3,495 of these instruments in use. There are, besides, many thousands in use on our railways.

These instruments are invaluable where several stations are placed on one wire, and especially on railways where sometimes as many as 20 or 25 stations are on one circuit. There is no instrument, that I know of, so thoroughly competent to discharge its duty on railways as this single needle.

Several improvements have been made in the single needle instrument within the past few years. The principle one is in the form of the needle. One cause of trouble in working these instruments is due to lightning. Lightning is the greatest enemy that the telegraph engineer has to contend with. It bursts and fuses his wire, it destroys his apparatus, and shatters his poles. Its effect on these needles is to demagnetise them. The needle on the face of the dial is attached to a needle inside which is a magnet, and, when powerful currents pass through the coils of the galvanometer, the needle has its magnetism whipped out of it, and it is then said to be demagnetised. To cure that evil, one of the earliest improvements in this apparatus was introduced by Mr. Alfred Varley, in the shape of permanent magnets, that caused the needle inside the coil to be magnetised by induction. The needle is merely a piece of soft iron, out of which lightning could not whip its magnetism, and, therefore, to a certain extent, the defect was cured. But, in severe thunderstorms, the magnetism was sometimes whipped out of the permanent magnet itself, so that, altogether, it was not a permanent cure.

Another improvement in this respect was made by Mr. Spagnoletti, of the Great Western Railway Telegraph Department, who induced the needle by the use of two larger and more powerful horseshoe magnets, and by doing so rendered the instrument less liable to damage by lightning, and also, at the same time, more sensitive to currents. These various forms of needle instruments will be on the table, available for your inspection after the lecture.

There are some accidents to which this instrument is subject, besides those of lightning. For instance, at Dursley, on April 29th, 1874, an instrument failed to work because the front needle had been broken by a cat playing with it. Cockroaches have been found to stop the working of these instruments in the Brazils, by swarming inside the coils. In damp weather, too, the moisture collecting on the ivory pins causes the needle to stick to them, and they have to be moved by shaking the instrument, or prevented from sticking by the constant attention of the clerk in keeping the pins dry. In Ireland this defect was once remedied in a very curious way. The postmaster of a certain town wrote to the head office to say that "for seven months after we commenced to work the telegraph at this office we were troubled with the needle sticking to the ivory pins, and, after the telegraph clerk left, matters seemed to grow worse. I read with care every work I

could get on magnetism and electricity, all to no purpose. One day, when receiving a message, I was perplexed in the extreme with the needle sticking, and really did not know what to do, as I could not get the message. Suddenly three words flashed across my mind. I applied the remedy, a cure was immediately effected, and from that day to this I have never suffered from the same cause, and the needles give a better click than formerly." The postmaster was told that this was very satisfactory, but was reminded that his report did not show what were the three magic words used which assisted him out of his difficulty. He then replied "'chalk your bobbins!' I have no recollection of ever having heard of this being done before. I chalk each pillar or pin on the inside, and think of patenting the idea, or perhaps the Postmaster-General will send me a Victoria cross for my invention!"

The next instrument to which I will call your attention is the Morse ink writer. This apparatus is used at stations where the business is heavier than those at which the single needle is fixed. Morse invented a telegraph instrument in 1832, but that known as the "Morse" did not come into existence until a much later period; in fact, not till 1844, and at that time he introduced what is now well-known as the Morse alphabet. On the diagram here is the "Morse" alphabet. It is generally assumed that the Morse alphabet consists of dots and dashes, but the chief essential in the use of this alphabet is not the dot or the dash, but the space between either of these elements employed to form a letter. Different spaces separate the elements of a letter, the letters of a word, and the words themselves.

The Morse Printing Alphabet.

A - —	N — -
B — - - -	O — — —
C — - — -	P - — — -
D — - -	Q — — - —
E -	R - — -
F - - — -	S - - -
G — — -	T —
H - - - -	U - - —
I - -	V - - - —
J - — — —	W - — —
K — - —	X — - - —
L - — - -	Y — - — —
M — —	Z — — - -

Note.—In the original Morse alphabet the combined letters "Ch" are represented by four dashes, but this signal is not now used, and "Ch" is signalled as two separate letters.

In the formation of this alphabet a lesson was taken from the printer's fount. There it was found that the letters which occur most frequently in the English language were E, I, T, and consequently for these letters the simplest signs were used; E is represented by a single dot, I by two dots, and T by a dash. The letter A is represented by a dot and dash, B by a dash and three dots, C by a dash, dot, dash, dot, and so on, as you will see from the signs given above. You will observe that the greatest combination of these signs used to represent any one letter is four.

For the numerals the following signs are used:—

Numerals.

1 - — — — —	6 — - - - -
2 - - — — —	7 — — - - -
3 - - - — —	8 — — — - -
4 - - - - —	9 — — — — -
5 - - - - -	0 — — — — —

Bar of division (horizontal bar representing fractions as in $\frac{2}{3}$), — — — — —.

Bar of division (oblique stroke representing shillings as in 2/3), - - -

Note.—The numerals are used on the Morse printer only. On the single needle, numbers and fractions are spelt at full length, with the signals "F I" before, and "I F" after them, to indicate that the words between must be transcribed in figures.

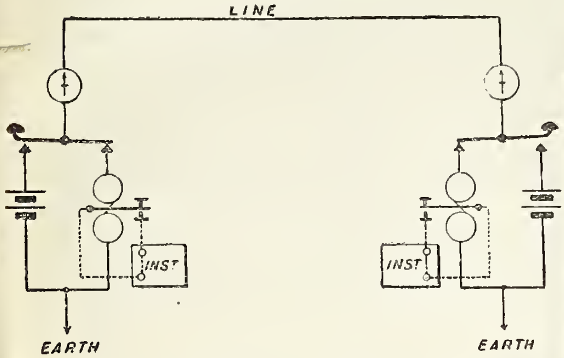
The space between the elements of a letter is equal to one dot, that between letters of a word is equal to three dots, and the space separating words themselves is equivalent to six dots.

You were shown in the first lecture that by passing a current through an electro-magnet attraction and repulsion are produced. This attraction and repulsion gives us mechanical power, which we turn into account, and make it the means of indicating by long or short beats the elements of letters that are sent by the current. Here is a Morse embosser. To the armature of the electro-magnet is attached a lever, at the end of which is a style. Each time the armature is attracted the bar is moved, causing the style to press upon paper ribbon, which is mechanically drawn over a ground wheel, and if a succession of short currents be sent through the electro-magnet, as many dots are embossed upon the paper ribbon; or, if currents causing the armature to be held down for a sufficient time to represent the "dash" element of a letter, as many dashes appear on the paper. But this embossing is difficult to read unless you catch the shade falling upon the dots and dashes, which operation severely taxes the eyes. In 1854, Thomas John, an Austrian engineer, devised a plan by which these dots and dashes could be made in ink; and before you is one of the earliest ink-writing instruments employed, made by the eminent firm of Siemens and Halske. There is exactly the same motion as in the embosser, but instead of the style at the end of the lever, a disc is fixed, which rises and comes in contact with the paper in the reverse direction to which it is rotated. The disc dips into a small well containing ink, and as it revolves continually in the reverse direction to that of the paper, it presents ink on its circumference to the paper, and so records dots or dashes which ever may be sent. With a simple ink-writing instrument such as this it is difficult to get currents of sufficient strength to attract the armature at great distances with force enough to make a mark on the paper. In that case what are called relays are introduced. Let us suppose a line of telegraph as shown on the diagram on the next page (Fig. 7).

You have a battery, with a key, by the simple depression of which a current is sent to line. You also have a galvanometer which shows whether the current flows or not, and at the end of your line wire you have a "relay" which receives the current, however weak, and immediately brings into force a more powerful current, which passes through the electro-magnet of the instrument, and records the signals received.

There has, perhaps, been more ingenuity exercised in the construction of these relays than of any other pattern of apparatus used. Here is one of the

Fig. 7.



SINGLE CURRENT CIRCUIT · WITH RELAY

first relays ever used. It was introduced by Wheatstone to send an alarm, and was produced by the decomposition of water. The gases accumulated by the decomposition of water drove up, by pressure, a column of mercury, which made contact, and so sent an alarm. Another form of relay was by the mercury contacts made by a fork fixed at the end of a needle, as you see here. One of the earliest form of relay introduced into America, and that which is almost universally used over there now, is the Morse. It has certain advantages over other kinds, but being non-polarised, is abandoned in this country, and superseded to a great extent by that known as Siemens' relay. Here is another relay known as Stroh's, which is extremely delicate, and moves with the slightest current, but the most recent one is that known as the Post-office standard relay. All these instruments will be better understood by a little careful inspection; it is quite impossible for me, in the time allotted, to explain their construction. They all perform the same function, viz., to bring into play stronger and and more constant currents.

The instrument I have explained to you records dots and dashes on the paper, but you will have noticed that in making these marks a certain sound or beat occurs. Sometimes we read by this sound, and the current performs the dual function of attracting consciousness, either through the eye, by reading the dots and dashes on the paper, or through the ear, by the sounds. We have here, in order to show the actual working of the telegraph, an instrument fixed on a wire, which communicates with the Central Telegraph Station in St. Martin's-le-Grand. It is one of the simplest kind of instrument, a sounder, To show you how these sounds can be translated into the Morse alphabet, I have brought a little instrument (kindly made for me by Mr. Theiler), which emits a fairly loud tone of given pitch. [By long or short notes, Mr. Preece made evident the facility with which sounds represented the symbols of the Morse alphabet.]

This little sound-giver is very similar to one brought out some years ago by Mr. Brittain, and was called (after him) "Brittain's Busy Bee."

But the sounder instrument, instead of emitting a musical tone, simply gives a thud, though I would ask you to notice that the sound produced by the attraction of the armature is quite distinct from that made on its recoil. This kind of instrument is used to a very large extent (almost universally) in America; it is a specimen, in fact, of the "pony" sounder used in America, which I brought over on my recent visit. We have rather altered it, and, I hope, improved upon it. We will now call up the attention of the Central Station, and you will have a practical illustration of the manner in which telegraphic business is carried on. To call up an office certain signals, which represent the code of that office, are sent. Every telegraph office throughout the kingdom has its code; Liverpool, for instance, is L V; Manchester, M R; Birmingham, B. M., and so on. The code for London is T S, which letters (representing the telegraphic centre of the world) are the initials of Telegraph-street, where the central office was formerly situated.

[T S answered the call, and Mr. Preece's assistant received a portion of news which had reference to Parliament then sitting.]

That is the actual process adopted for the transmission of news and ordinary messages. You will readily understand upon what trifling differences in sign or tone words depend. The insertion of a dot here, or the omission of a dash there is sufficient to cause an error. But in spite of this it is very surprising and pleasing to find that out of the 100,000,000 messages repeated every year so few errors are made.

A dot will convert the word save to rave; pound is easily transposed into found, and the words dead and bad are made up of precisely the same number of dots and dashes, as

D	E	A	D	B	A	D
— - -	-	- —	— - -	— - - -	- —	— - -

the only difference being the insertion of a space; and a very sad message was sent not very long ago announcing that a favourite daughter was "dead" instead of "bad"—the signals for DE having exactly the same element as B, as shown above. After hearing this you will be not surprised that when a party of young ladies was announced as having "arrived all right," the message was delivered as "arrived all tight;" and that also when a husband went to Brighton to secure apartments, and arranged with his wife that if he found apartments he would telegraph for her to come, but if unsuccessful would return home; he telegraphed, "home to night," but she received the message "come to night," and the result was that they crossed on the road. Again, a friend of mine was in Manchester, and his only child was at home unwell, he suspected, with the measles; his wife telegraphed "Rash all gone," but he received a message "cash all gone." I could repeat these errors to any extent, many ludicrous, many sad, but all simply dependent upon a very trifling change made in this rather uncertain alphabet. Still, as I said before, when we think of the enormous number of messages transmitted every year, we can only be surprised at the care and skill which prevents a greater proportion of errors.

I want particularly to call your attention to the difference between the ink-recorder and sounder,

The latter is the instrument now coming into use with tremendous strides. It has had to force its way a good deal against prejudice and ignorance, but it is steadily and surely making its way into this country. Its extreme simplicity is most striking. In the apparatus upon which you have just heard the news received, we have everything sufficient to fully equip a telegraph station. We have a table upon which is placed your key, galvanometer and sounder, with battery underneath. The galvanometer is simply for the purpose of indicating when a current is being received should the sounder fail. The chief advantage of this instrument is its economy. The difference between the cost of a sounder and ink-recorder is very great. Again, the clerk who reads by the sounder, and writes down the message, uses each sense separately, but with the recorder he has to refer to the slip with his eye each time he has written out as much as he noticed by the previous glance, and this constant referring means liability to error. With the sounder the clerk's ear drinks in the sound, and it is the same to him exactly as if the sender were simply speaking to him. The sounder ensures wonderful accuracy in the transmission of telegrams; and one of the most marked effects of the introduction of this instrument has been the reduction in the number of errors made, the reason being that the hand follows the ear; if the ear has learned to read accurately by sound, the hand is sure to send accurately by sound, and this is invaluable, because where we have a good sound reader there we have a good sender, and the result is accuracy. Also, as the clerk has not to glance his eye from one paper to the other, but simply to write on as fast as he can, the rapidity of the working is increased, because he simply writes down as fast as he is sent to, and, in point of fact, the rate at which messages are taken off is simply limited by the rate at which the clerk can write. It instils in the clerks who use this apparatus care and reliance. It has a kind of disciplinary agency about it, and those who are skilful sound readers invariably turn out to be self-reliant, accurate, and valuable operators. But the principal advantage attaching to this sounder is that it in reality increases the speed of working, and thereby increases the capacity of the wire for the transaction of business. Certain disadvantages are asserted as belonging to sound reading. One objection is the loss of record. That is a very conservative notion. It is supposed that by having a record of each message that you have a check in case of error. But, as I told you, errors on the sounder are not made, and, therefore, no check is needed, and those who support the old instrument, on account of its recorder, can only be classed amongst the staunchest Conservatives that we possess. Again, it is said that there is some difficulty in reading the sounder, when other noises take place in the room or shop where it is fixed; but I can only say that in the Central and other large offices where sounders are used and many noises prevail, the sounder is in great favour, and has never been objected to on the ground of its being interfered with by extraneous noises. At other times it has been said that listeners can stand outside a telegraph office and hear all that is going on. They may do so in America, but they cannot in England, for in a well-appointed office the sounder, being placed behind the public counter ought not to be heard (though I am afraid it often is), but, even if it is, I do not think it is likely that people who could read by sound would find it worth their while to hang about to catch unknown and unexpected messages. I do not think there is much value, if any whatever, in these objections. There are about 1,380 of these sounder instruments in use in the Postal Telegraph Department. In the next lecture I will show you the application of sound to duplex and quadruplex working.

There is another kind of sound-reading instrument, called the "Bell." This instrument was introduced by Sir C. Bright and his brother, Mr. E. Bright, as far back as 1853. It is after the principle of one of the earliest form of instrument, which also recorded its alphabet by different sounds, invented in 1837 by Steinheil. The signals are received on plates varying in sound, one representing a dot and the other a dash. [Several letters of the alphabet were sent on the instrument, also the words Society of Arts.]

The signals when sent on this instrument at a rapid rate, seem to form, to an unpractised ear, quite a confusion of sounds, but I have no doubt there are many persons in the room who can easily distinguish the signals sent, and convert the apparent conglomeration of sound into ordinary language.

There are 277 of these bell instruments in use in the postal telegraph service.

Another form of sound-giving instrument, called the "Neale," from its inventor, has lately been introduced. It follows the principle of the bell, the different sounds being caused by the beating of the single needle upon metal cylinders of different tone. It is made by substituting for the induced coil of the single needle instrument an "acoustic" coil of the "Neale" pattern.

[The letters of the alphabet and a few phrases were sent upon an instrument of this kind.]

It possesses all the advantages of the single needle, with the addition of those of sound reading, and is certainly calculated to simplify some of the difficulties of telegraphy. The instrument has only lately been introduced, and though likely to be largely used in the postal telegraph service, time has not yet permitted of its being generally adopted.

There are many other instruments in daily use which I have no time now to refer to.

There are instruments which record the letters of the alphabet in bold type upon paper slip. One of the most valuable, and which is very largely used on the Continent, is the Hughes type-printing instrument. It is also used in England by the Submarine Telegraph Company, and the *Times* newspaper has private wires to Paris and Vienna, and all the news that you see every morning from "Our own Correspondent" in those towns is transmitted direct, and printed in clear type on paper slips by this instrument, which can on its receipt be immediately handed over to the compositors to set up. We have only a few of these instruments in the Post-office. It was used very largely at one time, but we found that it was not equal to the speed required. They are, perhaps, a little slower in the transaction of business on the Continent, or have not yet arrived at that tremendous development of business that we experience, and which compels

rapidity in the performance of professional business. Nearly every night during the sitting of Parliament over 500,000 words are despatched from the Central Station, and the transmission of these 500,000 words, by the time they arrive at their destination, reach over 2,000,000 words, so that this large total which appears in the newspapers, presented at the breakfast tables all over the United Kingdom, is transmitted over the telegraph wires. The instruments which enable us to deal with this enormous amount of traffic I will bring before you on a subsequent occasion.

There are also instruments which absolutely transmit one's handwriting. I have here specimens of writing and sketches that have been transmitted by the D'Arlincourt writing apparatus. This apparatus is an adaptation of an invention by Mr. Bakewell as far back as 1848. By it we are able, not only to reproduce writing, but sketches and characters of any sort or kind. Here is a sketch I drew myself, of something that is supposed to be a steamer, passing some rocks that are supposed to be the Needles; but it requires a vivid imagination to distinguish either the one or the other. This picture was transmitted over 400 miles of wire, and accurately reproduced, with all its imperfections on its head. Here is also a drawing of a fish that was reproduced in like manner; as also some Chinese characters, written by a member of the Chinese Embassy, who visited our central station, and saw the instrument at work. This is the only instrument I know of capable of reproducing Chinese and Japanese characters, that are really pictures in themselves, and do not convey language to the mind by the aid of the A B C, or elements of language, but by pictorial productions.

We have here also an instrument that produces writing in another way. It is the new writing telegraph of Mr. Cowper; and the principle that has guided Mr. Cowper in the construction of his instrument is the mathematical fact that the position of any point in a curve can be determined by its distance from two rectangular co-ordinates. It is upon a similar principle that the course or curve followed by a ship is known by means of latitudes and longitudes given during the passage. The letter O, for example, is represented by a circle which is made up of what we may call two equal components at right angles to each other, and if you are able to send these two components simultaneously along a wire you are able to reproduce the letter O. You will now see that on horizontal or vertical lines being drawn by the hand at the sending instrument, similar lines are reproduced by the pen at the receiving instrument. This is done by simply varying the strength of the currents flowing through the wires. Thus these currents act upon the pen at the receiving end with varying strength, and cause it to follow an exactly similar course to that traced by the sending hand. [Mr. Cowper wrote out several specimens.]

You see that, having the power to produce the two elements of letters, it is quite easy to compose or reproduce writing. The pen moves, at the distant station, as though moved by a phantom hand. The instrument will be open for your inspection while at work, after the lecture is over, for it is quite impossible, without a careful inspection, to make its principle clear to you all.

The only other instrument to which I have to make any reference is Sir Wm. Thomson's recorder. Here are specimens of the recording instruments so largely used for working submarine cables, and you will find a very neat specimen of some words that were transmitted by this means from Heart's Content to Valentia, 150 letters being sent in 100 seconds.

I need scarcely refer to telephones. You all know what telephones are, and here are one or two samples of the ordinary Bell speaking telephone.

I ought, perhaps, to say a few words about mirror working and apparatus of that kind, but it is needless for me to dwell upon them, for I am quite sure you are all anxious to see the writing telegraph.

I have just one word, however, to say about inventors and inventions. Inventors are a difficult class to deal with. An inventor is, to a certain extent, a species of monomaniac; he is a tremendous believer in his own invention, and however inapplicable it may be, you cannot possibly convince him that he is wrong.

"He that complies against his will,
Is of the same opinion still."

Nevertheless, there have been introduced a great many very valuable and ingenious inventions in this country, though the introduction of the telephone and phonograph from America caused many people to imagine that inventive genius had forsaken these shores for the New World, and had settled amongst our cousins on the other side of the Atlantic. I do not believe it.

For any invention to take root there must always be a necessity for it, and whenever a necessity arises, invention is sure to supply the want. There is no doubt that invention is wonderfully rampant, if I may so call it, in America, that is because necessities exist there to a much larger extent than with us. Moreover, invention in America is encouraged. The press takes up with wonderful alacrity anything new that is brought out, nurses it, and brings into notoriety.

It is very different with us. It is most difficult to incline the press in England to take up a new thing; and we are also labouring under this difficulty, that all individuals, who have failed to bring their inventions into maturity in their own country, always attempt to thrust them upon us, which makes us very sceptical, indeed, of new things, until they are proved to be sound and good. But whenever a necessity arises which is met by an invention, whether from America, France, Germany, or elsewhere, we always seize upon it and adapt it to our requirements without any national jealousy whatever. There is now among the audience, I see, a much respected American inventor, whose invention I hope to bring before you next meeting, and he, I am sure with others, will say that practical inventions for which a necessity exists are always appreciated and adapted in this country.

Next time I shall have the pleasure of bringing before you two very great American improvements that have been adopted by this country, and, I hope, by means of a wire between this room and the Central Telegraph Station, to show you in actual operation both duplex and quadruplex telegraphy.

MISCELLANEOUS.

THE SYDNEY EXHIBITION.

The English committee for this first International Exhibition held in Australia, have been successful in the collection of a large number of important objects, and the catalogue of the British Section, printed by Messrs. Johnson and Sons for the London committee, contains nearly seventeen hundred entries.

Generally speaking, the contributions are restricted to such articles as are in demand in the Colonies, but some are of a general character. Thus, there is a small collection of works of art, to which her Majesty the Queen, the Prince of Wales, President of the British Royal Commission, the Society of Arts, the Art Union of London, and a number of artists and amateurs have contributed; and a committee of the Royal Institute of British Architects has made a collection of designs and drawings of buildings and decorations.

In the mineralogical section there is a collection of marble, granite, slate, and other materials, raw and manufactured, artificial marble and cements, including a collection of specimens by Dr. Le Neve Foster, consisting of sixty-three specimens from Cornish mines; also others by Mr. J. R. Gregory, illustrating Professor Geikie's primer and Professor Bonney's manual of geology.

The metal trades are naturally amongst the best represented. There are thirty exhibitors of iron, steel, wire, hoop, rails, saws, and tools from Sheffield, Stourport, Tipton, Brierley-hill, Bilston, Kidderminster, Dudley, Nottingham, Dundee, Hadley, Glasgow, Stourbridge, and Sunderland, including many of the most important firms.

The contributions of machinery, plant, and apparatus of various kinds amount to about two hundred; they consist mainly of such useful items as the tools and materials used by miners, engineers and blacksmiths; woollen machinery, machine-tools, wood-working machinery; apparatus for dressing skins, hides, and leather, and the tools of the usual handicrafts. But there is also a collection of motors, hydraulic and pneumatic machinery, lifting machinery of all kinds, locomotives, steam cranes, traction engines, and all the appliances of the same important class, railway plant, working stock, signal and other apparatus.

The classes relating to navigation and transport include many important contributions, and some of an unusual character, such, for instance, as a model of the wool warehouses and portions of the South West-India Dock of London, with a full description of all the elaborate arrangements made for facilitating business. The London and St. Catherine's Dock Company have also sent models, plans, and photographs of their docks, warehouses, and wool departments. These grand establishments are each capable of receiving something like a hundred thousand bales of wool at a time, and Australia is doubtless quite ready and able to fill them.

The Inman Company has contributed a full rigged ship model and oil painting of its magnificent screw-steamer, *City of Berlin*; the Orient Steam Navigation Company have sent models, pictures, and plans of their *Lusitania* and *Orient*; and there are numerous other contributors in the same section.

Agricultural machinery, implements, and tools are, naturally, fully represented; there are nearly a hundred exhibitors, including all the large implement makers; and every article of use to the tiller of the soil, from a pocket-knife to steam ploughing machines, and from a tin pail to a cast-iron water-tank is represented. In this section, also, are about fifty exhibitors of various articles of food, preserves, condiments, and potable liquors.

In the various classes which are included under the head of chemical manufactures, there are fifty or sixty contributions of drugs, chemicals, perfumery, disinfectants, essences, baking, and other powders, manures, explosive substances, fusees, &c.; this class cannot fail to create much interest in a colony which still looks to the old world for the supply of many of its wants.

The ceramic class comprises from thirty to forty exhibitors, principally manufacturers of ordinary and useful ware, but including several of the oldest and most famous makers of porcelain, fine earthenwares, &c. Glass of all kinds, from common green bottles to engraved vases, is contributed by eight or more firms, including some of the most important in Great Britain; and there are besides several excellent contributions of stained glass by London, Birmingham, and Smethwick firms.

In all exhibitions, articles of furniture and accessories form a large section; in the present case the contributors number more than a hundred, including many of the best-known names in the various classes. To these may be added more than fifty contributions of hardware, ironmongery, and other metal articles for ordinary use, including several specimens of iron safes of an elaborate kind.

Textile manufactures, with clothing, jewelry, and other accessories, naturally fill a large space; the exhibitors amount to two hundred, and the contributions include almost every thing worn or carried. Besides ordinary objects for personal use, there is a capital collection of portable firearms, cartridges, and accessories, by nearly thirty firms, including most of the most eminent names in London, Birmingham, and Reading. Other classes of manufactures are fairly represented; but it is not necessary to mention them specially.

It should be added, however, that education and science have not been overlooked; and that amongst the most prominent contributors are the Lords of the Admiralty, the Science and Art Department, and the School Board of London.

The above short analysis will show that the Sydney Commissioners were not too sanguine in expecting British manufacturers and others to contribute to the first International Exhibition held in the antipodes. The actual number of industrial exhibitors from Great Britain is about 800. France sends 350 contributions to the same section; Germany, nearly 600; Australia, 170; Belgium, 230; and the United States, 150.

ECONOMIC USES OF THE HOP-PLANT.

Dr. Emil Pott calls attention to the many useful purposes for which various parts of the hop-plant may be applied over and above the mere production of the umbels employed in brewing, to which alone the growers' care appears to be given at the present time. To begin with, the tendrils furnish a good vegetable wax, and a juice from which a reddish-brown colouring matter can be extracted; further, their ashes are greatly valued in the manufacture of certain Bohemian-glass wares. Of still greater importance is the fact that a pulp for paper-making can be prepared from them, and though the goods thus manufactured cannot be satisfactorily bleached, very serviceable unbleached paper and cardboards are got from this raw material. The fibres can also be used in the manufacture of textile fabrics. Experiments in this direction extend to a far back date, and in Sweden yarn and linen making from hop fibres has long been an established branch of industry which is constantly increasing in importance and extent. The separation of the fibres has hitherto presented considerable difficulties, but these appear to be effectually overcome by the process recently devised by

Dr. Weiss, of steeping them for 24 hours in cold water containing 5 per cent. of sulphuric acid, or for 20 minutes in boiling water to which 3 per cent. of the acid has been added. Other mineral acids, such, for instance, as muriatic, may be similarly employed. Nordlinger, of Stuttgart, also has patented a plan of rendering the fibres very flexible and tractable. This he effects by boiling them in closed vessels with soap and soda, and after thorough washing treating them with diluted acetic acid, and then again washing in cold water. Another use to which hop twigs may be put is that of wicker-work. Lastly, it must not be forgotten that the young shoots form a very palatable vegetable, not inferior to asparagus in delicacy of flavour, while the leaves, and the spent hops themselves supply an excellent food for live stock generally, and especially for sheep. Dr. Pott contends that, by due recognition of some or all of these numerous virtues of the plant, growers can always repay the cost of cultivation without reference to the hop itself, which of course will remain the chief object in view, and can render themselves more independent of the great fluctuations in the price of the latter to which they are at present subjected.

RECENT EXPERIMENTS ON AGRICULTURAL CHEMISTRY AT ROTHAMSTED.

At the late meeting of the British Association for the Advancement of Science, held at Sheffield, Dr. Gilbert, F.R.S., at the request of the President of the Chemical Section, gave some account of results obtained at Rothamsted, of which the following is briefly the substance. He stated that, in the course of the experiments conducted there, wheat had now been grown for 36 years in succession on the same land, barley for 28 years, oats for 9 years, root crops for more than 30 years, and beans also for about 30 years. Experiments on an actual course of rotation had extended over 32 years. And, lastly, experiments had been conducted on the mixed herbage of grass-land, in Mr. Lawes' park, for 24 years. They found minor distinctions in the manurial requirements of different plants of the same natural family; but very great distinctions in the requirements of plants of different natural families. The gramineous crops are very low in their per-centage of nitrogen, and yield but a small quantity of it per acre. Yet nitrogenous manures are very effective when applied to such crops. Leguminous crops, on the other hand, are very high in their per-centage of nitrogen, and yield a large amount of it per acre. Yet nitrogenous manures are of little avail to those plants, and potass manure is especially effective. The difference in the manure-requirements of plants of some other natural families was also pointed out.

Much more complicated, however, was the problem, when experiments were made upon the mixed herbage of grass land, where they might have 50 or more species growing in association, representing perhaps 20 natural families. It was at once found that the manures which most favoured gramineous crops grown separately on arable land brought forward the gramineous plants in the mixed herbage. The plants of other natural families also exhibited characteristic susceptibility to the manures employed. In fact, any manure, that is, anything that increases the growth of any species, induces a struggle, greater or less in degree, causing a greater or less diminution, or a disappearance, of some other species. Hence, the twenty different plots in the experiments in question soon showed as many distinct floras. Tables were exhibited illustrating the variation in the number of species, which was in some cases 50, and in others under 20; and the per-centage by weight, and the amounts per acre, which the different natural families yielded, were also shown.

There were very great differences, not only in the flora, but also in the character of development of the plants, degree of luxuriance, tendency to join leaf or stem, to mature, or otherwise, and so on; and, with these, there were also very great differences in the chemical composition of the produce. The dry matter of the mixed herbage contained (per cent.) in some cases one and a half times as much nitrogen as in others. The per-centage of potass in the produce varied as one to two, and the amount of potass yielded per acre as one to five in the different experiments; and there were considerable differences among the other constituents. The produce of the respective natural families, when normally developed, and when ripe, may be said to possess a characteristic composition within certain limits. Yet the composition varied immensely according to the conditions supplied, the species grown, and the character of development induced. Thus, the ash of the separated gramineous produce showed a variation in the per-centage of potass of from about 24 to about 40, the ash of the leguminous produce from 12 to 33, and that of the mixed produce of the other natural families from 17 to 37.

One point of especial interest was the difference in the amount of nitrogen taken up over a given area by plants of different natural families. The measurable, or as yet measured, annual deposition of combined nitrogen from the atmosphere was quite inadequate to account for the amounts taken up by the vegetation. Even unmanured land may lose more than this by drainage. It was assumed by some, that some plants assimilated the free nitrogen of the atmosphere, whilst others did not; and if this were established, many existing difficulties would be explained away. But Mr. Lawes and he (Dr. Gilbert) considered that the balance of the direct experimental evidence on the point was decidedly against the supposition of the assimilation of free nitrogen. The balance of existing indirect evidence was also in favour of the supposition that the different plants only took up combined nitrogen, and chiefly from the soil. It was shown, by reference to their experiments at Rothamsted, that in the growth of wheat or barley for many years in succession on the same land, without nitrogenous manure, the annual yield of nitrogen in the crop gradually diminished. With this there was a diminution in the per-centage of nitrogen in the soil. In the case of the root crops, where, under similar conditions, the diminution in the annual yield of nitrogen was greater than in the case of the cereals, the diminution in the per-centage of the nitrogen in the soil was also greater. In the case of beans there was also diminution in the yield of nitrogen in the crop, but still much more was yielded over the latter period than in either wheat or in barley. The bean field did not, however, show a marked reduction of nitrogen in the surface soil. In the case of the mixed herbage experiments, very much more nitrogen was yielded by the application of potass manure; in great part due to the increased growth of leguminous plants, and here they found a great reduction in the per-centage of nitrogen in the soil. In the case of clover, grown for many years in garden soil, the per-centage of nitrogen in the soil was also very largely reduced. Part of this reduction might be due to loss by drainage, and in other ways, but the indication was that the leguminosæ had derived their nitrogen from the soil.

Admitting that the sources of the whole of the nitrogen of vegetation were not conclusively made out, they nevertheless considered that the existing evidence was against the idea of the assimilation of free nitrogen by plants, and in favour of the opinion that the nitrogen was mainly, if not entirely, derived through the medium of the soil. Independently of the combined nitrogen which soils receive from the atmosphere, or by manure, most have large accumulated stores derived from past ages of vegetation, with perhaps greater normal annual supplies than at present, and certainly less removal, and therefore gradual accumulation. On this point it may

be mentioned that a sample of Oxford clay, obtained in the recent Sub-Wealden exploration boring, at a depth of between 500 and 600 feet, showed, on analysis at Rothamsted, approximately the same per-centage of nitrogen as the subsoil at Rothamsted taken to a depth of about four feet only. An acre of moderately clayey soil and subsoil may indeed contain several thousand pounds of combined nitrogen within the depth to which the roots of growing crops descend.

ELECTRIC LIGHT AT THE BRITISH MUSEUM.

In continuation of the experiment for lighting the reading-room made last autumn with the Jablochkoff system, the authorities of the Museum have this week given a trial to the Siemens system. Eleven lights in all have been fitted up, and of these four are placed in the reading-room, four in other parts of the building, and three outside it. The four in the reading-room are placed, one in the centre and three equidistantly around it. They are supplied with continuous currents, each from its own Siemens dynamo-electric machine. Of the lights in other parts of the museum, two are placed in the entrance-hall, one in the reading-room corridor, and one in the Greek gallery. In the courtyard in front of the building are two more lights, while another is placed in the rear, near to the engine and machine-house. These seven lights are supplied from one Siemens machine, producing an alternating or divided current. It will thus be seen that two different systems of electric lighting are employed, both, however, being on the Siemens principle—the four lights in the reading-room being produced by continuous currents, and calculated to be each equal to 4,000 candles, the seven other lights, which are estimated at 400 candles each, being produced by an alternating current, and being connected in one circuit about 1,200 yards in length. The lights in the reading-room are suspended from the roof, and are enclosed in octagonal lanterns filled in with ground-glass, and having circular reflectors placed over them. The other lights in the building and that at the engine-house are also suspended, while the two in the fore-court are placed on standards. They are all enclosed in ground glass globes. The experiment is considered to have been successful, as an excellent and agreeable light is stated to have been both produced and maintained.

LIGHTNING CONDUCTORS.

Mr. G. J. Symons, F.R.S., Secretary of the Lightning Rod Conference (30, Great George-street. S.W.), writes:—"In the summer of 1878 delegates were nominated by the following societies, viz., the Royal Institute of British Architects, the Society of Telegraph Engineers, the Physical Society, and the Meteorological Society, for the following purposes:—To consider the possibility of formulating the existing knowledge on the subject of the protection of property from damage by electricity, and the advisability of preparing and issuing a general code of rules for the erection of lightning conductors. The delegates have held several meetings, and have already collected, firstly, from the manufacturers of lightning conductors, and secondly, from the members of the Royal Institute of British Architects, a large amount of thoroughly practical information. Several of their number are also engaged in forming abstracts of the salient features of the literature of the subject. The members of the Conference are, however, most anxious that their report should be as trustworthy and as exhaustive as possible, and they have therefore instructed me to ask you to assist them by publishing this epitome of their proceedings, and allowing them to invite correspondence upon the points mentioned below."

In order that the report shall be as exhaustive as possible, Mr. Symons further asks for information on the subject, more particularly such as is indicated as follows:—"Full details of accidents by lightning, stating especially whether the building struck had a conductor or not. If there was a conductor, state its dimensions, construction, mode of attachment to building; whether its top was pointed, distance of its upper terminal from the place struck, nature and extent of the connection between the conductor and the earth, and whether the earth was dry or moist; whether the conductor was itself injured, and whether the conductor or the point struck was the most salient object in the vicinity. Information is also desired, either verbally or by sketches, as to the position of metal spouting and lead roofing relatively to the point struck, and to the conductor. Details of the thickest piece of metal melted by a flash of lightning are much needed. Unimpeachable evidence of the failure of conductors is much desired, as such failures would be extremely instructive."

GENERAL NOTES.

Visual Defects in Engine-drivers.—At a recent meeting of the London Association of Foremen Engineers, Mr. M. Reynolds, in a paper on practical engine-driving, referred to a source of danger on the locomotive, which was perhaps, more important even than that arising from colour-blindness. This was the blinding effect of the glowing white light of the engine fire, a brief glance into which, he said, rendered the person who looked for a time unable to recognise the colours of the signal lamps. He also pointed out that there are other visual defects besides colour-blindness, for which it is just as necessary to examine engine-drivers.

University College, Bristol.—University College, Bristol, is commencing its fourth session. The calendar states that there were 448 students in the college in the second session; and in the third 576, of whom 355 were men and 221 women, 172 came in the daytime and 404 in the evening. Good progress is being made by the engineering department, which is designed to afford a thorough scientific education for students intending to become mechanical or civil engineers, surveyors, or architects. The course for engineering is such that students can pursue it during the six winter months of each year, and the council of the college have arranged with the leading civil and manufacturing engineers in the neighbourhood to receive in their offices and workshops during the summer months, students whose position relatively to the firms would be that of articled pupils. In the ordinary course on chemistry and in the laboratory care is taken to explain the chemical composition and properties of the more important materials employed in construction, the effects of the atmosphere on them, and the chemical principles involved in sewage and ventilation. Engineering students in their second year will be invited to attend a special course by Professor Letts on metallurgy, explaining the method of extraction, purification, &c., of the useful metals and the properties upon which their utility depends; also a special course by Mr. Sollas, giving an account of the structure, properties, and localities of the chief building stones, clays, and other substances used in construction; of the selection and preservation of building stones, with practical work in the field and the laboratory. Professor Thompson gives a course on surveying and another on geometrical drawing, and a special course on those portions of technical physics which concern the building industries. There are in addition general courses in chemistry, mathematics, mechanics, experimental physics, geology, botany, political economy, logic, law, modern history, English literature, Greek, Latin, ancient history and literature, French and German. There are evening classes at low fees in most of these subjects. The college is also giving, with the co-operation of the Worshipful Company of Clothworkers, instruction at Stroud in chemistry and in the textile industries.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

UNION OF INSTITUTIONS.

The following Institutions have been received into Union since the last announcement:—

Albion Chapel Young Men's Institute, Southampton.
Young Men's Christian Association, Newcastle-on-Tyne.

CANTOR LECTURES.

RECENT ADVANCES IN TELEGRAPHY.

By W. H. Preece,
Electrician to the General Post-office.

Lecture IV.—Delivered May 12th.

Duplex and Quadruplex Telegraphy.

I commence a rather difficult task to-night, and that is to endeavour to make an audience comprehend the operation of conducting telegraphy on one wire, so as to transmit four messages at the same time. Such an operation is called quadruplex telegraphy, and quadruplex telegraphy depends upon two separate and distinct operations. One is the power to transmit two messages at the same time in the opposite direction, which is called duplex telegraphy; and the other is the power of transmitting two messages in the same direction at the same time, and that is called diplex telegraphy. So I perplex you with several "plexes." In the first place we have simplex telegraphy, which you saw last time. Now we have duplex, diplex, and quadruplex; and all other kinds, beyond quadruplex, of sending messages, are called multiplex.

Time to-night will not allow me to go absolutely into all the details of these operations, but there are many books in different languages that enter into the matter very fully, so that those who are interested in it may pursue it still further. Besides the books published in England, there is a very complete one published in America by Mr. Prescott, the electrician to the Western Union Telegraph Company, that goes very fully into the history of the process. Then, in France, we have a capital work by Count Du Moncel. In Germany, we have two excellent works by Professors Zetche and Schellen.

There are many means of carrying out these different processes, but in order to be quite clear, I will confine myself to-night simply to one. Last time I showed you how simplex telegraphy was carried on by sound. The mere taps produced by the armature of an electro-magnet produced sounds, and from these sounds we were able to produce the Morse alphabet. [Several letters were sent on a sounder.] These sounds are produced by currents of electricity passing round a core of iron, converting that iron into an electro-magnet, and thereby causing the attraction of a mass of metal. Currents of electricity vary in two ways; firstly, they can flow from here to Liverpool, say; or they flow in the other direction. So that their direction varies, and according to the variation in their direction, so will they produce polarity in an electro-magnet. For instance, here I have an electro-magnet, and suspended above it is a needle, which, when the current goes in one way, is attracted on one side, and when the current goes in the other way is attracted to the other side. You see when I press this key down I cause a current to go in one direction, and by just a simple reversal I am able to cause that magnet to be attracted in the other direction. I do that in this way. This electro-magnet is wound with two separate and distinct wires. When the current goes through one wire it sends this needle (a long needle attached to the armature of the electro-magnet) over on one side; and when the current goes through the other wire it sends the needle over in the other direction. Currents of electricity invariably divide themselves through any number of paths that are left open to them, exactly in proportion to the obstruction or resistance, as it is called, which the wire offers to the current. If I bring my key down now, the current which I am sending from the battery below me divides between two wires of unequal resistance. The strong current goes in one direction, causing the needle to be deflected in one way. If I weaken the current going through the one wire and strengthen the other, then I cause the needle to go on the other side. Now, the first thing that I have to do to enable me to work duplex, is so to let these two currents pass through my instrument that they shall exactly neutralise each other. That is, that the current which goes in one direction shall be of exactly the same strength as the one which goes in the other direction. Here I have a little bobbin of wire that represents my line (you may conceive it, if you like, to be a wire extending from here to the Central Station), and here I have what is called a rheostat, an instrument which gives me exactly the same quantity of wire; it exactly represents a line, and is, in fact, an artificial line. Now, I know that the current going through one wire is very much stronger than the current going through the other wire, and by making this artificial line equal to the actual line, we shall get the two currents of exactly the same strength. [This was shown on the electro-magnet.]

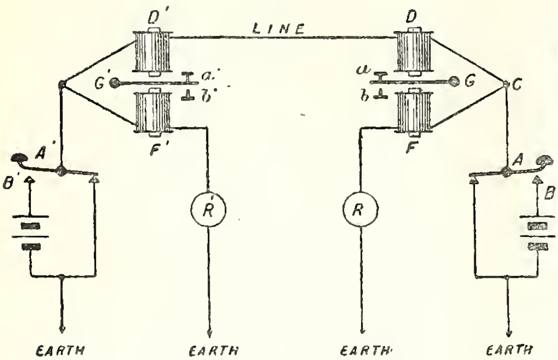
You will see that there is absolutely no effect whatever upon the needle. If I increase this line, at once you see the balance is disturbed; if, on the other hand, I increase the other line, you will also see that it is disturbed; and when I make my two lines of exactly equal length electrically, you will find no current whatever goes through. At the present moment, assuming that our little bobbin there were an instrument like this little sounder at the other end of it, every time I tap my key here

currents pass through this instrument without affecting it, but they affect the one at the other end. If, by any means, while I am tapping, any disturbance of the line takes place, you see at once we get an indication of it. There are those two facts that I want you to bear in mind. First, the currents divide themselves exactly in proportion to the resistance opposed to their progress; secondly, by taking advantage of that, we can so equalise the effect upon a magnet as to produce a complete neutrality. I want you to bear this in mind, because the usual notion of duplex telegraphy consists in imagining that there is something that passes or crosses; some such idea as two trains, running in opposite directions upon one line, passing each other in some way or other.

In this process of duplex telegraphy, there is nothing that passes; it is a case of neutrality. The currents flowing in opposite directions neutralise each other, and it is the advantage that is taken of this neutralisation that is made use of to produce telegraphic sounds and telegraphic alphabets. To assist you thoroughly in bearing this in mind, I am obliged to make use of a diagram; and it is rather a difficult thing for those who are not in the habit of examining diagrams of apparatus and circuits to follow exactly what takes place.

Here I have a diagram representing a circuit fitted up in duplex (Fig. 8). This series of thick and thin

Fig. 8.



DUPLEX SYSTEM

lines represent a battery, the thin lines always representing the copper, the thick line the zinc of an ordinary battery. The same at the other end. The line wire you may imagine to be of any length, say 100 miles. This diagram shows the portion of the apparatus in London, as also the portion of the apparatus, say, at Birmingham.

A is the key, similar to the one I have here. It is an ordinary key, that simply brings the two points, A and B, in contact, and causes the current to flow from the battery, the other end of the battery being in connection with the earth, E. When the key A is depressed, the lever comes into contact with B, and causes the current from the battery to flow. The current flows through the key A to point C, whence it has two paths open to its progress. If the resistance of the two paths be exactly equal to each other, then the current that flows in each of the two branches is exactly the same. We will assume that the paths are exactly equal to each other, and, therefore, the current flowing through is exactly the same. One half the current flows along the upper branch, round the coil, D, and converts it, for the time being, into an electro-magnet, which attracts or repels, as the case may be, the tongue, G. When the tongue, G, is moved, it comes over and makes contact at *a*. The current, as I say, passes through coil D, and then along the line wire to the coil D^1, in passing through which it attracts or repels (as the case may be) the tongue, G^1; from there it goes to the key, A^1, and from the key, A^1, it goes direct to the earth. So that you see one-half of the current from this battery goes through the electro-magnet, D, through the line, through the other electro-magnet, D^1, to the earth at the other end, and as it does so it causes the tongue there to work (and the tongue of this relay completes a local circuit, which I have not shown upon the diagram, because it makes the diagram much more confusing). The last time I had before you a diagram showing how relays were connected up with sounders, and how they caused the latter to work. This tongue, in moving, causes a sounder to work, so far as regards the upper magnet.

Now let us take the lower half. The current, as I have said, divides at C, half going to line, the other half going from C to F, through the coil F, through the artificial line which is marked R (this is, in reality, precisely similar to that which I had in my hand, and represents an artificial line that we can vary from 1 mile up to 1,000 miles), and to earth. Now, then, you will see that every time this key A works, the current is split into two parts of exactly equal strength, the one pulling the tongue in the one direction, and the other pulling the tongue in the reverse direction, the effect being, as in the present case, when it is acted upon by currents of exactly equal strength in opposite directions, simply *nil*. Therefore, every time we move our key we have no effect upon our instrument here, but the current through the line passing the electro-magnet D^1 and going to earth, is not opposed to an equal and opposite current, hence it acts upon the tongue, G^1, and, therefore, makes sounds or marks at the distant station. Therefore, every time we depress the key A, the current passes through our instrument without affecting it, and dots and dashes represented by the depressions are made at Birmingham.

That is the first operation. Now let us take the other one. Birmingham is working to London. He depresses his key, N^1, causing currents to flow from his battery as in the home station. The currents divide at C^1, one half goes through the coil D^1 to London, works London's coil, D, and so to earth, and back again to the sending battery. The other half flows through the coil, F^1, acts upon the tongue, G^1, in the opposite and reverse direction, and passing through the artificial line, R^1, comes back to the battery. Therefore, when Birmingham works to London, Birmingham also sends his currents through his own instrument, but they are neutralised there, and produce no effect; they proceed along the line to London, work London's instrument, which records the dots and dashes sent. So that you see we have, first of all, London working to Birmingham alone, next, we have Birmingham working to London alone.

Now, we want to see what happens when London is working to Birmingham at the same time that Birmingham is working to London.

Well, when you send a current along a wire—let my rod, for instance, represent a wire, and a current is sent from my right hand to my left hand in one direction, and at the same moment I send a current from my left hand in the other direction, if these currents are of exactly the same strength, they neutralise each other, and the result is that you get no current over your wire at all. So, if I sent a current from London to Birmingham, and at the same time a current is sent from Birmingham to London in the other direction, the result is that no current at all is received, and we get no magnetism. But the other half of the current in each case that passes through the coils, F and F^1, acts on the tongues, G and G^1, and attracts them to their respective stops, b and b^1, causing marks or sounds to be made. And just in the same way at Birmingham, when Birmingham's current is neutralised by that from London, the second half of Birmingham's current is allowed to act upon the coil, F^1, and pulls down the tongue, G^1, and the result is that while London is working to Birmingham, the instrument at Birmingham continues to mark, and when Birmingham is working to London, the instrument at London continues to mark, so that really the marks that are made in London are by London's own current, and those made in Birmingham are made by Birmingham's own current. Just watch the process. Suppose by pressing the key A down I send a dot, my current divides at C, one-half goes through D, the other half through F, they are neutralised, and we get no effect at all. If, however, at that same moment Birmingham were sending a dot to me, my half through D would be neutralised, and I should get the dot, because the second half of the current through F would work, and the dot, although it is made by my own current and by my own key, is actually the representative of the dot that would have come from Birmingham, but which is neutralised and lost on the line, as it were. Just in the same way, while Birmingham is sending his dot to me, his half of the current through D^1 going along the line is lost and neutralised, but the other half going through F^1 is allowed to operate, and Birmingham also has his dot. So that you see while London and Birmingham are working together, whether sending dots or dashes, or combinations of the two, the signals are recorded by the second half of the currents sent, just as though the current came all the way from the sending station.

I have said that the currents exactly neutralise each other. That is upon the assumption that the line itself is absolutely perfect, that is, that the insulation is perfectly good, when no current is lost, and the two currents in opposite directions are exactly neutralised. But that is not necessary nor essential. We cannot get lines, in this country at any rate, whatever they may do in others, perfect. Occasionally, as you know, we have a little rain. Sometimes we have fog, and there are other disturbances that interfere to a certain extent with the true insulation of our lines, and the result is that the currents that arrive at a distant station are not so strong as those that leave the home station. But it does not matter in duplex working, if you do not get absolute neutrality you get a difference between the two. If you balance your coil as I have done here, and have absolute neutrality, then if a current came from the distant station, the effect on this would be the difference of the two currents, and that might produce a very small deflection on this large needle, but it would produce a current strong enough to work the relay. And the curious thing is this, that whatever be the strength of the current arriving in London from Birmingham, whether it be equal or smaller than the current going out, the tongue of the relay is governed or moved by the differcnee between those two currents, and the difference between those two currents is always the strength of the received current. The tongue of your relay is always worked by the same force, whether that force be due to a received current, or whether it be due to the difference between the two currents, the one going through the upper half and the other through the lower half. Hence, practically, insulation does not interfere to any great extent. Still, when insulation becomes very bad in very bad weather, we have differences that render it difficult to work duplex, but when it is difficult to work duplex from such a cause, it is often also difficult to work simplex, and, as a rule, we find that as long as we can work our lines simplex, so long are we able to work duplex.

I have given you a slight idea of how duplex is worked, but perhaps you will get a better knowledge from seeing the actual process itself. We have the same wire brought into this room that was brought into it last week, and we have apparatus fitted here similar to that at T S (Central Telegraph Station). Every station throughout the country (as I told you last week) has its code.

We are now "calling up" T S, and there you hear his acknowledgment. We now ask T S to send some news to us, and while Mr. Cooper is writing out that news as it comes, Mr. Chapman will at the same time be sending something to T S. Now, you see while Mr. Chapman is sending to T S, his instrument is not affected in the least. The currents are being divided through a relay, just as shown on the diagram, and produce no disturbance whatever, but every time that T S is sending to us you find that marks are being made, at one time with his own current, at another with that portion of the additional current that I showed you acts upon the other side of the relay. [An extract from a meteorological wind and weather report received from T S was read out.]

This operation which you see going on between here and T S, is identically the same as would go on when speaking to Liverpool or Glasgow. It is a very curious thing how space seems absolutely annihilated with telegraphic instruments, and how a telegraphist feels himself in all parts of the world at the same time. Here we are in this room and hear what T S is speaking to us, and in like manner if we were speaking to Liverpool (L V) we could fancy ourselves there also.

In order to make the news we are about to receive from T S heard all over the room, I will take off the simple tapper, and will use one of Mr. Theiler's new sounders, which he has been kind

enough to supply me with. It will buzz at the signals in a loud musical tone.

[T S is asked to send V's, a succession of signals representing the letter V.]

I may tell you that these instruments have never been used before. We are trying a very risky experiment before your very eyes, and it is rather a difficult task to adjust apparatus and make things go before so many critical eyes.

[T S sends V's - - - —— - - - —— - - - ——.]

I may tell you that Mr. Cooper has never read by this instrument before.

Now, we have duplex working going on with our old friend the tapper, and you can hear the dots and dashes being given by the sounder, while something is also being sent to T S.

[T S then sent the message, "Latest from the Cape. The Boers' camp is broken up, and they have returned to their homes."]

I mentioned to you that one cause of disturbance in working duplex is due to variations in insulation. Another cause is due to variations in temperature. In some countries, where extremes of temperature occur, very great difficulty is found in working duplex, and even the passage of a cloud across a wire may produce sufficient variation to alter the balance between the two currents. Again, there is another cause of variation of working due to what are called "earth currents."

At certain seasons of the year, and at certain periods, there are strong currents of electricity flowing through the earth, and these currents enter our wires and produce disturbance. Where they come from, or what they are, we do not know; it is one of the mysteries of telegraphy, and although theories have been propounded, there is only one theory really that gives us the slightest clue to the cause, and that is a "new theory of terrestrial magnetism" by Professors Ayrton and Perry. Again, thunderstorms disturb the wires by producing what are called "kicks." Currents pass over the wires and break up a dash into two dashes, or they wipe out a dot, or put in a dot, and produce disturbances in this way; and it almost invariably happens that, when a thunderstorm is prevalent in Ireland, that the duplex circuits passing through South Wales and Haverfordwest are disturbed by these currents. In order to counteract all these disturbances due to insulation, changes of temperature, and so on, the artificial line which is marked R, or resistance, or *rheostat*, on the diagram, is varied. A box of this kind is so constructed that, as the line varies, so we can produce a similar variation upon our artificial line. Suppose, for instance, a wire going from London to Birmingham, and a severe rainstorm passed over Watford, and reduced the current coming from Birmingham; all we should have to do would be, to put in one of those pegs of the *rheostat*, as it is called, and that would compensate exactly for the variation produced by the rainstorm. Or, suppose that a severe storm were suddenly followed by bright sunshine, then a balance is at once produced by taking out one or two of these pegs; and so, by watching the working of results, by looking out for these disturbances, and by holding the pegs of these artificial lines, we are able to keep the artificial line exactly the same electrically as the working line, and so maintain the balance or state of neutrality in our sending instruments.

There is another difficulty that rather disturbs the working which I have not referred to, because it does not interfere with the principle of the thing, but on our lines we meet with a disturbance that is called "static induction." It is a hard word, and I do not want to use hard words if I can help it, but static induction means this, that the current seems to meet with what is almost analogous to friction in water or in gas passing through a pipe. Some people call it a kind of "sticktion." If you force water through a pipe some of it sticks to the sides of the pipe by attraction, and remains there, and so when you pass a current of electricity through a wire, a portion of it remains adhering to the wire, owing to the presence of this static induction, and the existence of this static induction was the real reason why duplex working was so long before it was introduced. I will mention that, when I speak of the history of duplex, I want merely to point out now that there exists this disturbance, and that it is compensated for by what are called condensers. Condensers are merely Leyden jars, and by their means the artificial line is balanced to equal the effect of the static induction on the line, and so the currents passing through are made equal and neutralised. But it is in submarine cables where this disturbance is chiefly felt, and I will allude to that little further on. It may be interesting to mention that we have in England now no less than 320 circuits working duplex on a system similar to what you see here, and the average length of each country circuit is about 150 miles, so that we really have about 48,000 miles of wire in this country working duplex, and the introduction of duplex working within the last seven years has been equivalent to the erection of 48,000 miles of wire.

Again the work done over a duplex circuit is really more than double what an ordinary wire can do. For instance, supposing a wire can convey 20 messages an hour, by duplexing you can carry 50 messages an hour, more than double, because there is no interference from questions being asked, or from repetitions being made, but the work passes in both directions from Birmingham to London, and London to Birmingham all day long, without any let or hindrance; and this equable flow really means more than double the amount of work. The progress of this duplex working was slow. It was invented in 1853, by Dr. Gintl, in Vienna, who, I believe, was in the service of the Telegraphic Administration of Austria. It was he who first introduced the compensation principle, but in 1854, Frischen, of Hanover, and Siemens and Halske, of Berlin, introduced this principle that I have explained to you to-night, which differs a little from Gintl's. Many others have tried various kinds of duplex; in fact, I heard an electrician once say, that "knowing how to work duplex it would be quite possible to invent a new duplex every week." I do not believe that, but at the same time, the numbers of systems of duplex that are in use are very great. From 1855 to 1868 duplex was what many things have been, simply a scientific toy. It had been proved to be practicable, it had been tried, but it had not been used, principally because it was not wanted. But in the year 1868, Mr. Stearns, a very distinguished American electrician (who was the head of one of

the Telegraph Companies in America, and who I have no doubt is in this room to-night, although I do not see him), had his attention attracted to the subject, and he found what was really the cause of the difficulty in working duplex, and that was the existence of the electro-static induction upon the line. When once you find the cause, it is very easy to find the remedy; and by introducing condensers such as are upon the table into the artificial line, Mr. Stearns succeeded in compensating for static induction, and by that means made duplex telegraphy what it now is. It is, however, in working cables generally that duplex becomes of such service. Many of the cables belonging to the Eastern Telegraph Company, in the Mediterranean, in the Red Sea, and across the Indian Ocean, have been duplexed by Mr. Muirhead. It is only lately that the Atlantic cable has been duplexed by Mr. Stearns himself, and he has done it with wonderful success. I have in my hand here two slips that were made only two or three days' ago, specially for illustration before you this evening, and which read "This is a specimen of Stearns' duplex working of Atlantic cable at about 25 letter words a minute." The ordinary rate of working the Atlantic cable, when I was there, was about 14 or 15 words in one direction, now it works 20 words in each direction, so that the capacity of the cable by the application of Mr. Stearns' principle has really been to increase its capacity more than two-fold.

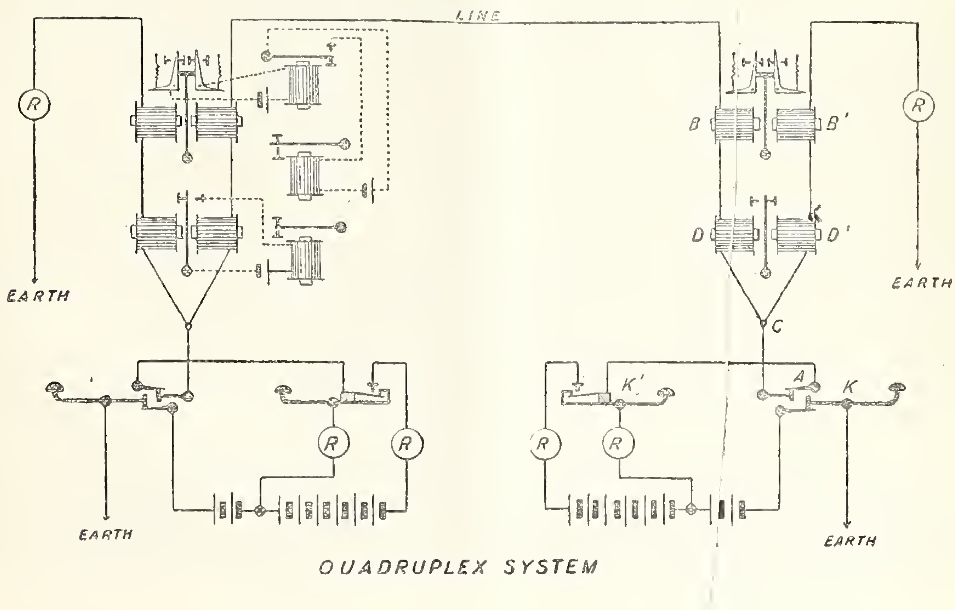
I cannot occupy your time by referring to the various systems of duplex. There is a very pretty system by Mr. G. Winter that is in use in India, and also largely in America, where it is known only under the name of D'Infreville. It has been applied by Mr. Fahie in Persia. But we have recently been trying another form of duplex here, the invention of Mr. Theiler, which dispenses with the second current by mechanical means. Mr. Stearns, in 1872, also applied mechanical means to compensate, as did also Mr. Gerritt Smith in America. There is no great value in it; I merely mention it as an illustration of some of the changes that have been attempted in duplex working.

The next system that I told you of was "diplex." Duplex, as you see, is working in opposite directions at the same time. Diplex working means working in the same direction at the same time; but, as this is part and parcel of the quadruplex working, I must speak of it at the time that I speak of quadruplex working.

You see on the diagram that, in duplex working, we are able to compensate the effect of our outgoing currents, and it does not matter one straw what the strength of these outgoing currents may be. Suppose I send a current through these coils from one cell, I have neutrality and no effect; if I send a current from 100 cells, I still have neutrality and no effect. On the other hand, if I send a current from Birmingham to London, say from one cell, I get a very weak effect. If I send it from 100 cells I get a very strong effect. In this diplex system of working, we send two systems of currents from one station to the other. To explain that to you I must refer you to this diagram. I mentioned that we can either vary the direction in which the current goes, or we can vary its strength. The secret of quadruplex working is this—that we have one relay which works with a change in the direction, and we have another relay which works with a change of strength. The currents that work the former relay are weak, those that work the latter relay are strong. Any reversal in a current, whether it be a weak one or strong one, will work the former relay; any change in the strength of the current, whether it be in one direction or the other, will work the latter relay. So that if we send a weak current from the distant station, and change the direction, we work the former relay, and if we send a current in whatever direction, and alter its strength, we work the latter relay.

To produce that alteration in direction or strength

Fig. 9.



QUADRUPLEX SYSTEM

we have two keys, K and K¹ (Fig. 9). These keys are upon the table; here is one, and there is the other. You will see that wherever the key, K, is depressed, it alters the direction of the current. Now, let us see how the current flows. Starting from the battery, the current goes along this wire to A, and on to C, where two paths are open to it, one half goes through the coil B, then through coil D, and on to the line; the other half goes through the coils, B¹ and D¹, in the reverse direction, producing neutrality there, and so on to line; thus we do not interfere with our instrument, but we send a zinc current to line, and when the key, K, is depressed, the lever is lifted and presses against A, the zinc goes to earth through the key, and the copper goes to line. So that when the key is up the zinc goes to line, and when down copper goes to line, and by working the key we are simply sending positive and negative currents to line. The key K¹, on the other hand, whatever be the direction in which the currents go, simply increases the current, as shown in the diagram, from 20 cells up to 80 cells. If it changes it from 20 cells to 80 cells, it increases it four times, so that every time I depress the key K¹, I increase the strength of current going to line four times. Every time I depress the keys, K and K¹, I do not affect my instrument at all, but in the one case (key K) I send reversals to the out station, and in the other case (key K¹) I send stronger currents. Just transfer yourselves to the other end of the line, and imagine these currents coming in from the other direction. These weak reversals come through D, and work the relay and its tongue and the sounder in connection with it, then pass through B, but being weak currents, although they attract the tongue of D, they do not affect the tongue of B, the springs of which are strong, and oppose the current, preventing it from acting, and therefore, the currents that operate relay D are innocuous on relay B, because they cannot overpower the springs. If, while working this relay, D, the strength of the incoming current be increased four times, then it overpowers the spring of B, causes its tongue to move, and, therefore, makes a mark. So that, you see, if I make dots and dashes with my weak currents, relay D works; if I make dots and dashes with my strong currents, or from key K¹, relay B works, and as D works from reversals quite independent of strength, and B works from strength quite independent of reversal, the result is that, when key K works at the distant station, relay D responds, and when key K¹ works relay B responds, and when they both work together they both respond, and the result is you get diplex working; and, as you work this system in connection with duplex, you are able to work two messages in one direction at one time, two messages at the same time in the other direction, and four messages are passing. [The quadruplex arrangement on the table was here set going, and messages passed between the Central Telegraph Station and the lecture-room.] There you have four messages passing at the same time on one wire.

The history of this instrument is interesting. It was conceived as far back as 1855. Stark, of Vienna, seeing the possibility of duplex working, also conceived the possibility of sending two messages in the same direction at the same time, and, therefore, he suggested the possibility of quadruplex working. Again, in 1873, Mr. Oliver Heaviside showed theoretically, in the *Philosophical Magazine*, how it was possible to work quadruplex, and even multiplex. Any number of messages can theoretically be sent at one time; in fact, by this process that you see, it is possible by a series of these keys to vary the strength of your current one to seven times, and by so doing you may send as many as seven, eight, or any number of messages at the same time, but practically, although experiments have been made with the sexiplex (which means six messages at the same time), we practically do not want to send more than four, and the four that the quadruplex gives us are quite enough to meet our wants at the present moment. It was Mr. Stearns also, who, in 1874 first took out a patent, and who first practically showed how quadruplex working was possible; but it was in America where it was first brought into actual work by the Western Union Telegraph Company. Mr. Stearns' ideas were taken over to America by Mr. Orton, the President of the Western Union Company, and when he returned to America he put the matter in the hands of Mr. Prescott, the electrician, and Mr. Edison, their scientific adviser, and after two years of very hard work, Mr. Edison succeeded in introducing the principle that I have explained to you, by which one relay is worked by reversals, and the other relay by increasing the strength of the current. But the principal source of success of the working of the quadruplex is due to the invention of a compound relay; to this peculiar relay whereby the strength of the current overcomes a spring, independent of its attraction, and that is the invention of Mr. Gerritt Smith, the assistant electrician to the Western Union Company. Of course, when the quadruplex has been proved to be practicable, other inventors stream into the field, and we hear of "quads" being introduced in India and other places, and doubtless, in time, somebody else will be able to say that "if called upon he will be able to invent a new quad every day." At present the quadruplex has not been applied to any great extent in England. We have only six circuits working. No doubt we should have more if we wanted them, but we do not want them. In America, however, there are no less than 63 circuits worked quadruplex in the Western Union Company's service, and being anxious to have authentic information, I telegraphed on Saturday to Mr. Prescott to let me know how many circuits they had at work, and I received a reply from him this morning in which he says that "We have 63 quad circuits working, and send eight million messages per annum over them. Our New York and Chicago quad averages 1,200 messages per day, from 8.0 a.m to 6.0 p.m." But that is not a very astonishing amount of work. There are many circuits in this country worked by other apparatus (that I shall have the pleasure of showing you next time) with much greater results. But it speaks well for the quadruplex system that there are so many instances in which it has been introduced.

I have not much more to say, and in a moment we will set this quadruplex circuit going again, so that you may have a close view.

I only want to refer to another system of telegraphy (which I cannot show you in operation)

which has been introduced in France and Austria, known as the multiple system of working by Meyer. By this system four, five, or six messages are sent on the same wire at the same time, but it is not based on a system of neutrality, as in these two systems, but is based on a principle of cutting up time. In a type-printing instrument, such as the Hughes, the type wheel revolves for each letter, and time is consumed by such revolution. Meyer and Baudot, who showed a beautiful apparatus at the French Exhibition this year, introduced a system by which time is cut up into slices as it were, and each slice is apportioned to a given message, and, by distributing the time to different stations, they have shown how it is possible to send four or five messages simultaneously, and have increased the capacity of circuits very much.

Another system, called "harmonic telegraphy," has been introduced, patented by Mr. Cromwell Varley as far back as 1870. Mr. Varley took advantage of the principle of the telephone, and, by sending musical sounds through a wire, and taking advantage of the sympathy between the vibration of one instrument and another, he succeeded in introducing a system by which messages can be picked out by sound, at the same time that the wire was absolutely being utilised in sending Morse signals. This principle has been practically carried out by Elisha Gray in America, and I am in hopes of seeing the apparatus over here, and of having the power of giving it a trial. It is rather curious that it was this system of multiple telegraphy, based on harmonic sounds, that led Professor Bell to the introduction of the telephone, and, by the reverse process, it was the invention of the telephone that led Elisha Gray to the invention of the harmonic telegraph, so that they are both dependent on each other. There is also Mr. La Cour, in Denmark, who has introduced a system of harmonic telegraphy. We have not tried it in England yet, and I have no apparatus to show you, and so can only allude to it in this cursory way.

Next time I shall have the pleasure of bringing before you what I believe to be the most perfect system in the world, that is, the automatic, which is used nightly for the distribution of news all over the United Kingdom.

MISCELLANEOUS.

TECHNICAL EDUCATION.

Professor Charles Graham delivered the introductory lecture before the Faculties of Arts and Laws and of Science, at University College, London, on the 1st inst., taking Technical Education as his subject. He said:—The universities have hitherto been to blame in their one-sided view of training for the business of life, equally with those who can see no good in any other training but the empirical. The man of science has been content to assume that the right mode of training a young man who is to be engaged in manufacturing pursuits, is to teach him the general laws of science, leaving him to acquire in after-life a knowledge of the facts and processes of his particular industry, and then to apply the general principles of science, acquired at college, to the elucidation of the complex phenomena brought under his notice. I will grant that it sometimes happens that a young man of exceptional power of reasoning, combined with trained habits of observation, will, in time, master the details of his manufacturing process; and, having given exceptional powers to the elucidation of the operations carried on, will be able to improve them; but at what a needless waste of time and energy! He has to conquer for himself, under conditions very unfavourable for the work, much of what has long since been done in the application of science to technology. It must not be forgotten that throughout Europe there are hundreds of workers who are daily adding to our knowledge of technical processes. Such knowledge as I speak of can be more rapidly acquired under the direction of a competent teacher, aided by ample apparatus and a good consulting library, than when not so aided, and when constantly interrupted by the daily duties of a factory.

While, however, a college education is manifestly incomplete if, at the latter stages of the student's training, the application of pure science to industrial operations be not an important feature, the mode or training recommended by many, and hitherto, in our country, that usually followed, viz., the acquisition of industrial knowledge by empirical methods, is even more unsatisfactory. This method consists in placing a young lad, it may be fresh from school and without any previous scientific education, in a factory, so that he may acquire a knowledge of what goes on there, and that most invaluable acquisition, "business habits."

Undoubtedly the so-called "practical" training is better adapted for carrying on, in a mechanical, imitative way, the processes as the pupil finds them (it may be that these are obsolete and bad, handed down by others), than for the intelligent examination of them and their substitution, if need be, by methods better fitted to the times in which he lives. I grant that an active mind, trained under a purely practical pupilage, does acquire a knowledge of a scientific fact here and there, and in time collects a great many facts or receipts, but based on no general foundation, disconnected, ill-understood because not illuminated by general laws; and, therefore, such knowledge conveys no power of increasing it. Hence arises a vast mass of utterly useless experiments, constantly made by the active-minded practical man, in the endeavour to improve his business. A previous scientific education would have shown him the impossibility or absurdity of many of the attempts thus made, and would have lessened the number of his failures, and have increased the number of his successes.

There is, perhaps, no more remarkable fact in the history of the arts and manufactures than that of the very high excellence obtained by ages of practice, aided solely by the knowledge and skill acquired from long years of empirical, that is, unscientific observation and experiment. The knowledge thus obtained has been built up by a long succession of labourers in the field, unaided by modern science and by modern scientific methods of observation and of experiment. Indeed, many of the arts we practise are too necessary for our well-being, and even existence, to have been left until such time as science could furnish us with the necessary knowledge to create them, if it were possible for science to exist without the previous accumulation of facts; and when one sees the high degree of excellence obtained by man in agriculture, metallurgy, and many other arts, solely by empirical methods, the practical man might excusably think that we may safely trust to the same energy and to the same methods for a continuance of progress.

He would be forgetful, however, of the fearful waste of time, and the innumerable errors and failures attendant on such methods, and of the important fact that the foreign scientifically-trained technologist would compete with him with wider knowledge and surer guides in the struggle for supremacy. Already our "practical"

training, so highly thought of but recently, has given the better-educated foreigner too much advantage; and it behoves us to use all our efforts, and the most advanced views as to education, if we would recover the ground thus blindly lost. How is it, that, even in our own country, we find so many young Germans occupying important posts in our manufactories? Why, solely on account of their scientific training. Indeed, some branches of chemical industry have been lost to us solely from their superiority in scientific knowledge, their superior power of investigation in fresh fields of industrial activity.

I think you will now agree with me that a scientific training is equally necessary with what is called a practical training. What is wanted is a system which will fulfil both of these indispensable requirements. This conclusion naturally leads me to discuss the means best fitted to secure professional training in technology; and as any adverse remarks which I might deem it my duty to make on the establishment of technical schools or institutions, such as are found abroad, and such as are advocated by some persons in this country, would be open to the objection that I am an interested witness, and therefore naturally over-estimate the advantages to be derived from such technical education (so far as it lies within the power of a college) being carried on in an institution devoted to general learning and the study of pure science, such as this college, King's, Owens, and others, I prefer to quote from a report of a committee appointed at a general conference held on the question of Technical Education at the Society of Arts, in 1868.

Among the members of the committee occur the following representative names:—General Codrington, Sir Daniel Cooper, Professors Hirst, Huxley, Fleeming Jenkin, Miller, Pole, Williamson, Dr. Price, Mr. Scott Russell, Admiral Ryder, Mr. Seddon, Sec. R.I.B.A., and Mr. Spiers, Pres. Architects' Assoc.

The committee limited their inquiry and the definition of "technical education" to the consideration of the education and professional training of the engineer, architect, chemical manufacturer, agriculturist, metallurgist, miner, merchant, and the officers of the army, navy, and mercantile marine.

"As regards the higher education, which will be first considered, two distinct schemes were discussed. Firstly, technical education might be given in special schools. Secondly, in institutions devoted to the general purposes of education. Special colleges for the education of the members of all the above professions are to be found abroad. The polytechnic schools of Germany and Switzerland were specially urged upon the committee as worthy of imitation. Sufficient evidence exists that in those institutions good scientific instruction is combined with practical training to an extent which Englishmen can hardly credit, unaccustomed as they are to see practical work learned otherwise than by practice. While, however, your sub-committee recognise the great merit of these institutions, they do not recommend them to imitation, but, on the contrary, resolved, 'That technical instruction, as above, should not, as a rule, be given in separate professional institutions, but in institutions established for general education.'

"The reasons for this conclusion may be briefly stated as follows:—

"Where training in polytechnic schools is adopted, the sytem of pupilage does not obtain; the number of years at the disposal of young men for their professional training does not allow of the combination of the higher school teaching with the teaching by pupilage, and of the two the latter is considered preferable. It would also be almost impossible, even if it were desirable, to substitute the foreign for the English system, and there is certainly no such clear advantage gained as would justify the attempt. As a minor reason, may be mentioned the great difficulty in obtaining duly qualified professors. Very few of the foreign institutions are self-supporting, and in this country, competing against the pupilage system, they would need to be supported by very large Government grants, such as should not be given to secure a doubtful advantage. Now, special schools of the highest grade would also, in many places, compete with existing universities and colleges, and it would be improper to support, by Government aid, the special school giving the narrower course of instruction rather than the university or college, giving the more general culture and more purely scientific training.

"The foreign polytechnic schools include a large number of classes for teaching pure science; these could be as well held, if not better, in universities or institutions giving a general education, and it is this part of the training which the sub-committee are chiefly desirous of recommending for imitation, not the practical portion, which is better given by the pupilage system. Again, our universities and colleges can readily adopt some courses on the applications of science, and thus provide such special teaching as may with advantage be given in class-rooms at much less expense than would be entailed by the institution of special schools. On these grounds the committee decided against the institution of special professional schools as a rule."

We see, therefore, that the authorities whose names I have read are of opinion that the study of applied science should follow a careful training in pure science, and that both should be given at the same institution, the practical portion of the technical training being, of course, given in the workshop or factory. The special technical institutions, such as the Polytechnic Schools of Zurich, Berlin, Vienna, the Ecole des Arts et Métiers, the Freiberg Mining School, the School of Mines in London, the Agricultural College at Cirencester, are examples of institutions set apart for education in some one technical subject. Of late the tendency of opinion in Germany has been rather adverse to this system; and many authorities now think it unwise to separate the study of applied science from the university; and, doubtless, this view will grow, for in addition to the objection of having a large number of professors teaching to small classes the same branch of pure science in various technical institutions, which must necessarily deteriorate the quality of the instruction, a deterioration not altogether removed by Government endowments, there are manifest advantages in having applied science taught in the same institution where general culture and pure science are efficiently taught.

The professors of technical subjects, when surrounded by an atmosphere of intellectual activity in literature and science, are not only stimulated by the energy around them, but also profit by the opportunity thus afforded of improving their own teaching from time to time by introducing new views and methods of investigation of value to their own special lines of activity. On the other hand, while teachers of technology thus benefit from the intellectual surroundings of a college engaged in the higher general education, the students of technical subjects benefit by intercourse with students engaged in literature or science from a more general point of view; and they have more opportunity of supplementing the curriculum of study, by acquiring a knowledge of a subject which they consider necessary for their special work in after life.

For example, the analytical chemist might wish, in addition to the subjects usually recommended for his study, to know something of materia medica and therapeutics; if so, the means of acquiring the knowledge are at hand at a university or a college embracing the widest culture. Similarly, in regard to mental philosophy, political economy, certain parts of English law, Spanish or Italian, free-hand drawing, and other subjects not usually included in a technical curriculum, he has but to turn to the faculty of arts, or laws, or

science, or medicine, to obtain what his special requirements need.

Now this teaching of applied science at a college for general culture—though new to many, who fear it will injure higher intellectual training—is, after all, no new thing. In the professions of medicine and surgery, years of practical experience have taught us that, valuable though pure scientific training may be, yet, without the special training at college and in the hospital in the applications of pure science, medical men would be but sorry guides in most cases. The eminence obtained by the School of Medicine at University College is everywhere recognised; but surely no one has found that the technical application of chemistry, botany, or physiology to the cure of disease has in any way lowered the character of the intellectual work done by former occupants of the chairs devoted to these objects, or by the distinguished men of science who now fill them.

The surest way to keep up a high intellectual standard any special training, is to surround it with conditions arranged for the highest mental culture; nor need anyone by so doing fear that higher intellectual work will suffer. I have been the more anxious to discuss the question of the influence of technical education on general culture at a college, because if such were to degrade the teaching of pure science, it would be a most grave evil. I am confident, however, that no such evil will follow; that as the application of physiology to the study and treatment of disease in no way lowers the intellectual labours of the physiologist, and the application of pure mathematics by the scientific engineer to elucidate important properties of building-materials, rather stimulates than lessens pure mathematical research, so will it be found, generally, that the needs of the teacher and student of technology will tend to stimulate the work of the teacher and student of pure science.

I will now pass to the consideration of the most fitting course of study for technical students; and it will be of great advantage to the elucidation of this question if I notice, briefly, the course of study which the medical student has to undertake in order to satisfy the requirements of the University of London for the M.B. degree.

The entrance or Matriculation Examination embraces the subjects of a good school education; this, of course, should be passed by the student before he enters college. I regret, however, that there are many schools which fail to impart a sufficient knowledge to the young lad, in order to enable him to pass the entrance examinations; hence, it follows that a part of the time at college is too often devoted to making good the deficiencies of the school education. There has, however, of late years been much improvement in this respect; and it is to be hoped that, before long, such deficient preparation for higher academic education will be but rare.

To return to the curriculum of the medical student. The University of London very wisely recommends that the first academical year after matriculation should be devoted solely to the study of the subjects of the Preliminary Scientific Examination; these are experimental physics, inorganic chemistry, botany and vegetable physiology, zoology and comparative anatomy.

Prepared with a good school education, the medical student during the first year works solely at some departments of pure science, and does not, or should not, commence the study of more professional subjects until his second year at college. The Bachelor of Medicine examination is divided into two parts, the first being devoted partly to scientific, partly to professional subjects, the second examination is wholly concerned with technical knowledge.

Thus the candidate for the first M.B. must pass in organic chemistry, physiology, anatomy, materia medica, and pharmaceutical chemistry; and for the second M.B., embracing the more professional and technical knowledge, the students must pass in pathology, therapeutics, and hygiene, surgery, and medicine in its three divisions of general, obstetric, and forensic.

The example of the scientific and professional training of the physician enables one to indicate the right course to be pursued in the scientific and professional training of the engineer and the chemical technologist, using this term in its widest sense; that is to say, we should follow the medical curriculum, and devote the first year to pure science, the second year chiefly to pure science, but also to some branches of knowledge more professional, the third year to such special professional and technical knowledge as can be acquired at college.

The time required to obtain the M.B. is four years, assuming the student to have been successful at each of the three examinations; but a part of this knowledge is analogous to the apprenticeship or pupilage in the workshop or factory. Now this part cannot be acquired by the technologist proper at a college; thus the agriculturist must work on a farm in order to acquire the practical knowledge of the management of land and of men, to buy cheap and sell dear, and to acquire business habits and knowledge. So with the engineer, whether civil or mechanical, a period of pupilage must follow academic training; similarly with those engaged in chemical industries, the practical knowledge must be acquired in the works or factory established, not for education, but for making money.

This part of the technical student's training can never, in my opinion, be efficiently given by an educational institution; and though some attempts in this direction have been made, I cannot admit that they have been successful. Manufacturing operations have to be carried on against keen competition; hence, the closest attention to expenditure is absolutely essential for success. The aims of an educational institution are different, and, consequently, this important qualification, together with much else which may be included in the term business habits and knowledge, can only be learned by contact and contest with the world.

I will not detain you by a detailed account of the subjects of study we deem necessary for the student of technology. It would occupy too much time to give a full curriculum of study for the civil, mechanical, or telegraphic engineer, the architect, and for the technologist in the various fields of activity in applied chemistry; suffice it that I state that only after a competent knowledge of pure science will the student in technology be encouraged to work at the applications of science; much depends on the previous amount of knowledge and the objects in life which the individual student may have in view; but in all cases it should be the aim of any educational institution that the training, so far as lies within its scope, be scientific, real, and, in a word, "thorough."

I have now finished the special remarks I wished to make on the subject of technical education, a subject, in the changed condition of trade, of pressing importance. England no longer possesses the almost exclusive hold of the iron industries, and to a great extent a similar loss of pre-eminence has taken place in some of our chemical industries; in cotton and linen goods other nations begin to compete with us in the markets of the world. Doubtless the high price of labour in this country has had much to do with stimulating foreigners to invest capital in industries at one time almost our exclusive territory; but the high price of labour does not account for all the change; other causes have been at work, and one of them, the want of higher scientific knowledge, of thorough professional training in the power of applying science to technical processes, has had much to do with the success with which foreigners have been able to invade our markets at home and abroad. The various schools of art design throughout the country will do much to aid us in giving a more artistic appearance to many of our manufactured articles; what is wanted even more is a professional

training of the masters and managers of our larger and more important manufacturing industries.

The establishment of chairs, museums, and laboratories for technology in colleges and universities in the United Kingdom is an imperative necessity; and in the absence of Government aid, we must trust to the public spirit of individuals and corporations.

The thanks of the public are due to some of the livery companies of the City of London for showing the way in this respect. In addition to a large scheme before them by which they hope to stimulate industrial knowledge throughout the country, they have, after careful consideration, determined meanwhile to aid University College and King's College in their mutual endeavour to add certain branches of education to their curricula. The chairs of chemical and of mechanical technology have been selected by the City companies for some assistance in this important work. Some aid has also been given by the friends of this college towards the new buildings necessary for the development of scientific education given here; but very much remains yet to be done in the establishment of laboratories, museums of models, specimens, and drawings. Doubtless this will come in time: since, judging by the past, we may safely assume that a continuance of assistance, whether from public-spirited corporations or from the public, will be forthcoming if we can show good use made of the aid given. So far as we in this college are concerned, we are determined to succeed; and I have a similar confidence in King's College.

The City companies have suggested the idea of having a certain amount of gratuitous education as a basis of their grant; and thus, by their enlightened action, some fifteen to twenty lads may attend gratuitously the lectures on chemical and mechanical technology at this college, and they have thoroughly arranged that three or four students ,selected from these, shall be able to work without payment of fees in the engineering and applied-chemistry laboratories. In this way promising young men, otherwise unable for want of means, will secure the advantages of a higher training. It is to be hoped that the example set by the City companies, and the munificent action of Sir Joseph Whitworth in another direction, will stimulate others to aid higher technical education, not only in London but throughout the country.

Some advocates of the dogma that "supply will follow demand" take for granted that no public aid is needed for higher culture or for higher professional education—ignorant of the fact that all such higher educational work never pays, and that unless State or private aid is forthcoming, none except the rich (and in many subjects not even the rich) can obtain such higher education. The establishment of laboratories, museums of specimens, models, and drawings, lecture-rooms, and other requisites is so costly that fees to meet the expense must be so high as to be prohibitory. Outside aid must be forthcoming; and though public benevolence is somewhat fitful and apt to run in grooves, yet on the whole it is better to trust to an awakened public spirit for aid in higher education than to the Government, which would certainly lay down conditions of examination that would bring about one dead level of uniformity, and mere surface knowledge throughout the country.

A new system of street lighting has lately been tried at Bristol, the invention of Mr. Kitt, the gas engineer to the Bristol sanitary authority. It consists in substituting for the ordinary burner in the street gas lamps, two smaller burners, consuming the same amount of gas, and placing between the two a convex lens, which acts as a reflector. According to the reports in the local papers, the experiments were successful, and the roadway was more effectively lighted than with the usual arrangment.

CORRESPONDENCE.

THE BRIDGE OF LESSART.

The Western Railway Company of France are at present engaged in constructing a branch line from Dol to Dinan; this has to cross the River Rance about two miles below the latter town by a single span at an elevation of about 100 feet. The method by which this has been accomplished is considered unique in this country, and deserves some notice. The iron portion of the bridge itself is of the usual diagonal construction, its length is 96·5 metres, or 314 feet, and its total weight 1,300,000 kilogrammes, equal to about 1,250 tons. It has been constructed by the Maison Jolly, of Argenteuil, a well-known firm, and has by them been put together on the line of railway immediately joining the intended span. Large wheels or rollers were placed beneath the bridge, and it was determined to push or propel the bridge across the stream by hydraulic power. In order, however, to regulate this operation, and to prevent its over-topping into the river below, a portion of a viaduct of a lighter construction, intended for another section of the line, has been temporarily attached or bolted to the fore end of the main span; this is about 150 feet in length, while another section is attached to the near end of the main iron bridge. It is evident that by adopting this method the fore end of the total iron construction will arrive at the supporting pier on the further side before the centre of gravity of the main span will have passed that on the home side; it will then be supported at both ends until finally placed in position. As soon as this is accomplished, the two sections of the lighter viaduct will be removed. To M. Morse, engineer-in-chief to the railway company, is due the credit for this bold and original conception, and under his able direction and supervision this great undertaking has just been successfully accomplished. Alfred S. Churchill.

Dinard, October 6th.

MEETINGS FOR THE ENSUING WEEK.

Mon., Nov. 3...Farmers' Club, Inns of Court Hotel, Holborn, W.C., 4 p.m. Mr. J. G. Edwards, "The Future Aim of the Farming Interest."
Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.
Society of Engineers, 6, Westminster-chambers, 7.30 p.m. Mr. Wilkinson Jones, "Modern Tramway Construction."

Tues., Nov. 4...Central Chamber of Agriculture (at the House of the Society of Arts), 11 a.m.
Biblical Archæology, 9, Conduit-street, W., 8.30 p.m. 1. Mr. Hormuzd Rassam, "Excavations and Discoveries in Assyria." 2. Mr. Edouard Naville, "Le Décret de Ptah Totunen en faveur de Ramsès II., et de Ramsès III."

Wed., Nov. 5...Geological, Burlington-house, W., 8 p.m.
Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m. Dr. Charles Symes, "Taraxaeum."
Society for the Development of the Science of Education, Memorial-hall, Farringdon-street, E.C., 7.30 p.m. Dr. Roth, "Physical Education and Hygiene in Schools."

Thur., Nov. 6...Linnean, Burlington-house, W., 8 p.m. 1. Rev. G. Henslow, "The Origin of the So-called Scorpoid Cyme." 2. Dr. Francis Day, "Instinct and Emotions in Fish." 3. Mr. H. M. Ward, "The Development of the Vegetable Embryo."
Chemical, Burlington-house, W., 8 p.m. 1. Mr. G. Auerbach, "Alizarin Blue." 2. Mr. C. O'Sullivan, "The Transformation Products of Starch." 3. Dr. H. E. Armstrong, "Note on the Formulæ of the Carbohydrates." Mr. T. Nakamura, "A New Method of determining Sulphur in Coal." 5. Mr. A. G. Smith, "The Bromine Derivation of β Naphthol." 6. Mr. J. S. Thomson, "Notes on the Dissociation of Ammonia, Iron, Alum."
South London Photographic (at the House of the Society of Arts), 8 p.m.

Sat. Nov. 8...Physical, Science Schools, South Kensington, S.W., 3 p.m. Captain Armstrong, "A Standard Cell."

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FRIDAY, NOVEMBER 7, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One-Hundred-and Twenty-sixth Session of the Society will be held on Wednesday, the 19th inst., when the Opening Address will be delivered by Lord Alfred S. Churchill, Chairman of the Council. Previous to Christmas there will be Four Ordinary Meetings, in addition to the Opening Meeting.

Candidates proposed for election as members are privileged to attend the Opening Meeting.

Ordinary Meeting.

The following arrangements for the Wednesday evenings before Christmas have been made :—

November 19.—Opening Meeting of the Session. Address by Lord Alfred S. Churchill, Chairman of the Council.

November 26.—"Suggestions for dealing with the Sewage of London." By Major-General H. Y. D. Scott, C.B., F.R.S.

December 3.—"Apprenticeship : Scientific and Unscientific." By Sylvanus P. Thompson, B.A., D.Sc., Professor of Applied Physics at University College, Bristol.

December 10.—"Art Vestiges in Afghanistan ; the Result of Some Recent Explorations in the Jellalabad Valley." By William Simpson.

December 17.—"The Panama Canal." By Captain Bedford Pim, R.N., M.P.

At the meetings after Christmas the following papers, amongst others, will be read :—

"Domestic Poisons." By Henry Carr.

"Gas Furnaces and Kilns for Burning Pottery." By Herbert Guthrie, C.E.

"The Utilisation of Slag." By Charles Wood.

"Art in Japan." By C. Pfoundes.

"The Trade and Commerce of the Yenisei." By Henry Seebohm.

"Modern Autographic Printing Processes." By Thomas Bolas, F.C.S.

"The History of the Art of Bookbinding." By Henry B. Wheatley, F.S.A.

"Art Ironwork." By J. W. Singer.

"The History of Musical Pitch." By A. J. Ellis, F.R.S.

"The Recent History of Explosive Agents." By Prof. F. A. Abel, C.B., F.R.S.

"Iceland and its Resources." By C. G. W. Lock.

"The Future of Epping Forest." By William Paul, F.L.S.

Foreign and Colonial Section.

The meetings of this Section will take place on the following Tuesday Evenings, at eight o'clock :—

February 3, 24 ; March 16 ; April 6, 27 ; May 18.

Chemical Section.

The meetings of this Section will take place on the following Thursday Evenings, at eight o'clock :—

January 22 ; February 12 ; March 11 ; April 8, 22 ; May 13.

Indian Section.

The meetings of this Section will take place on the following Friday Evenings, at eight o'clock :—

January 30 ; February 20 ; March 5 ; April 2, 16 ; May 7.

Cantor Lectures.

The First Course of Cantor Lectures will be delivered by Dr. Charles Graham, F.C.S., F.I.C., Professor of Chemical Technology at University College, London, on "The Chemistry of Bread and Bread-making."

The Second Course will be on the "Manufacture of India-rubber and Gutta-percha," by Mr. Thomas Bolas, F.C.S.

The Third Course will be by Mr. R. W. Edis, F.S.A., on "Art Decoration and Furniture."

Syllabus of the First Course.

Lecture I.—Introduction. Chemical composition of the chief bread-stuffs. The chief properties of starch, dextrin, starch sugars.

Lecture II.—Continuation of the examination of starch and its hydration products. The albuminous matter of flour, soluble and insoluble.

Lecture III.—Action of albuminoids. Rationale of kiln drying. Flour making. The dough. Action of moisture, heat, and albuminoids on starch.

Lecture IV. — Fermentation. Leaven. Yeast. Ferments of disease. Changes produced. The use of the microscope in the examination of yeast.

Lecture V.—Baking ; changes produced by heat. Aërated breads ; foreign breads ; biscuits, &c. Digestion of bread a continuance of fermentation ; conditions requisite. Conclusion.

Juvenile Lectures.

The usual short course of lectures adapted for a juvenile audience will be given by Mr. W. H. Preece on "Wonders of Sound" and "Wonders of Light." The dates for the lectures will be the 30th December and the 6th January. The lectures will commence at seven o'clock. Special tickets will be issued for these lectures.

Admission to Meetings.

Members have the right of attending all the Society's meetings and lectures. They require no c kets (except for the Juvenile Lectures), but are

admitted on signing their names. Every Member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the Members, but admission can also be obtained on the personal introduction of a Member.

Annual General Meeting.

The Annual General Meeting will be held on June 23rd, at four o'clock.

Evening Meetings of the Society will be held on the following dates, subject to any alteration which may be found necessary:—

	CANTOR LECTURES.	FOREIGN AND COLONIAL MEETINGS.	ORDINARY MEETINGS.	CHEMICAL MEETINGS.	INDIAN MEETINGS.
	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.
1879.					
November	— — — 24	— — — —	— — 19 26 —	— — — —	— — — —
December	1 8 15 22	— — — —	3 10 17 — —	— — — —	— — — —
1880.					
January	— — — —	— — — —	— 14 21 28 —	— — 22 —	— — — 30
February	2 9 16 23	3 — — 24	4 11 18 25 —	— 12 — —	— — 20 —
March	1 8 — —	— — 16 —	3 10 17 — —	— 11 — —	5 — — —
April	5 12 19 26	6 — — 27	7 14 21 28 —	8 — 22 —	2 — 16 —
May	3 10 — —	— — 18 —	5 12 19 26 —	— 13 — —	7 — — —

The Chair will be taken at Eight o'clock at each of the above Meetings.

CANTOR LECTURES.

RECENT ADVANCES IN TELEGRAPHY.

By W. H. Preece,

Electrician to the General Post-office.

Lecture V.—Delivered May 19th.

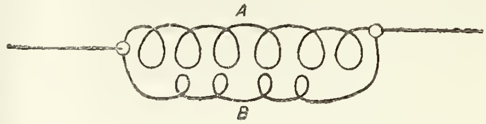
Automatic Telegraphy.

In all the different forms of telegraphic apparatus hitherto brought before you, we have been dependent upon the operation of a key controlled by the hand, the key being raised and depressed to produce dots and dashes, in the case of the Morse alphabet; or beats, representing the alphabet, on the dial instrument. This process of keying, of course, necessitates a considerable amount of skill on the part of the operator. It requires great practice to send these dots and dashes with regularity, so as to avoid errors; and the constant manipulation of the key also involves a considerable amount of endurance on the part of the operator. Hence, the operation of keying results in fatigue; a clerk goes to his instrument in the morning fresh, but after a few hours working, loses his strength, tires, and becomes slower in carrying out the operation; and perhaps gets, towards the end of the day, a little careless and indifferent, thus causing errors to arise. The maximum rate at which a clerk works is dependent upon the combination of strength and practice; and although operators have been known, who could transmit the Morse alphabet at the rate of 45 words a minute, 40 is a very high speed, and 35 is about the average of the most experienced operators. While 35, say, is the average rate at which a key can be worked, the receiving part of the apparatus, that which records the dots and dashes on paper, or that which registers the dots and dashes by sound, has a very much higher capacity. The capacity of an instrument is, as I will show you, practically almost unlimited. The rate at which instruments are worked is, no doubt, limited by the rate at which a clerk can write, but it very early struck telegraphists that if it were possible to replace by mechanism the terribly slow rate of manipulation by hand, it would be possible to reach the maximum rate of recording on an instrument, and thereby expedite the operation of telegraphy. Mechanism excels manipulation in several points. The transmission of currents by mechanism ensures precision in properly marking off the dots and dashes, or the signals representing dots and dashes. It secures precision in the form of spaces, and these, after all, are the principal element in the Morse alphabet. The precision leads to accuracy, and accuracy in transmission is a great essential in carrying out telegraphy. Practically, mechanism can be made to receive as fast as may be, and if it were only possible to secure a machine to send in place of the hand, the means are produced of enormously increasing the speed at which it is possible to telegraph. In receiving messages by mechanism at high speed, of course you exceed the rate at which a clerk can write, but you are able to divide your labour, and as the messages roll out on the Morse tape, you can cut it up into pieces, and hand the pieces round to different writers, to write out the messages received. Another great advantage in the use of apparatus worked by mechanism and at high speed is that it prevents the possibility of wires being "tapped." We know that during the American war it was a common practice to "tap" the wires, and receive information of operations going on; and again, one of the most serious objections recently brought against the introduction of the telephone, has been the facility with which it can be used to tap wires; but where wires are worked by mechanism and by automatic apparatus, the possibility of tapping entirely ceases. It is a very curious fact that the very first form of the telegraph introduced by Morse, in America, in the year 1844, was one in which automatic apparatus was used to transmit dots and dashes. A type upon which the dots and dashes were cut was set up in sticks, and these sticks passed through an instrument, and the dots

and dashes were actually transmitted by mechanism. But it was not until 1846 that automatic telegraphy really took a practical form, and in that year Alexander Bain, a great genius in his way, conceived the idea of punching this alphabet of dots and dashes on paper, which punched paper passed beneath a brush or style, and so replaced the keys. This receiver was one of a differant kind to any I have shown you. It was dependent upon the action of the current on a chemical compound. When a current, for instance, passes through water, it decomposes the water into its constituent elements, oxygen and hydrogen. When it passes through sulphate of soda, it decomposes that sulphate of soda into sulphuric acid and sodium; or when a current passes through a solution of iodide of potassium, it decomposes the solution into its two constituents, iodine and potassium. I have here one of Bain's original form of receivers, and I will show you directly how the dots and dashes are produced by the decomposition of iodide of potassium. The dots and dashes, as they are sent by the transmitter, are received upon a slip of paper that has been saturated with iodide of potassium, and the signals are produced by the chemical action of the current on this paper. Here you see the puncher used to punch the dots and dashes; here is the transmitter which mechanically transmits the dots and dashes, and here is the beautiful receiver which chemically records the signals. But, practically, the Bain instrument was before its time. The speed attained on it was enormous. Lardner, in one of his books, details an experiment where from 1,000 to 1,100 words were recorded in a minute. But this was only on "short circuit," and only an experiment in a room. When the instrument was applied to a land wire, and became subject to all the disturbances that line wires are liable to—disturbances arising from insulation, or variations of the atmosphere and other causes—then the instrument began to be troublesome, and because it was not wanted, it was allowed to drop out of use. It was not wanted, for the simple reason that the business in those days was not sufficiently large to necessitate automatic or fast speed telegraphy. The system of Bain's was introduced in America in 1849-50, and it had a good run there, because it was started in opposition to the Morse apparatus. It has, within the last three or four years, again been resuscitated in America, because about four years ago active competition led to a reduction of rates, and this produced a considerable accession to business, which was a good opportunity for the reintroduction of the Bain's instrument. The effects of disturbances, such as were experienced in 1846-50 on an actual trial of the Bain's instrument in England (between London and Southampton), were removed in America by an Englishman of the name of Little (who had domiciled himself in the New World), by applying an electrostatic "shunt" or condenser to the receiving apparatus. And that prolific inventor that we hear so much about, Edison, also still further improved the instrument by substituting for the electrostatic shunt, an electro-magnetic shunt. A shunt, I must tell you, is merely a technical term applied to a wire or an electro-magnet that abstracts a certain amount of a current (see Fig. 10).

If the spiral, A, represent a wire, or magnet, and another spiral, B, representing another wire or magnet, were inserted so, this would be the shunt, or electro-magnet. Shunts are very frequently used in telegraphy for various purposes.

FIG. 10.



Siemens and Halske, also introduced, in 1853, an automatic system in Germany, and they have improved their system since then so much that, in 1876, it was used along the Indo-European line between London and Teheran. In 1858, another of our most brilliant geniuses in this country devoted his attention to automatic telegraphy, and that was Professor Wheatstone. From 1858 to 1862 Professor Wheatstone continued to devote his attention to this system of automatic telegraphy and, with the aid of the mechanical power and genius of Mr. Stroh, he succeeded in producing a thoroughly practical system, and this system (the Wheatstone automatic) was adopted by the Electric Telegraph Company of this country. The Wheatstone automatic apparatus consists of three parts—the perforator, the transmitter, and the receiver. The Wheatstone system differs from all others in the punching of its characters. On the table there is a puncher, and I will just ask Mr. Cooper to punch an alphabet so that you may see what the operation of punching really is. [Mr. Cooper punches a slip.] The puncher is a little apparatus, consisting of three pistons, which are capable of being depressed.

Here is a specimen of punched slip:—

o o   o o o o o o o o o o o o o o o o
o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o o
o o   o o o o   o o o o   o o o o o o o o

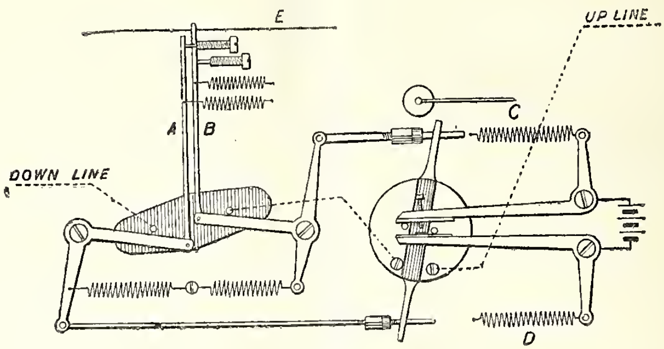
The centre one of these three pistons, on being depressed, punches the succession o o o o o o of holes in the centre of the specimen; the left-hand piston punches the holes, simultaneously, opposite each other, $\begin{smallmatrix}o&o&o&o&o&o\\o&o&o&o&o&o\\o&o&o&o&o&o\end{smallmatrix}$, as well as the centre; and the right-hand piston punches the holes, simultaneously, in a diagonal position, $\begin{smallmatrix}o&o&o&o&o&&\\&o&o&o&o&o&\\&&o&o&o&o&o\end{smallmatrix}$. The two holes $\left(\begin{smallmatrix}o\\o\end{smallmatrix}\right)$ opposite each other represent a dot, the diagonal ones $\left(\begin{smallmatrix}o&\\&o\end{smallmatrix}\right)$ a dash, and the centre holes are for the purpose of propelling the slip forward. A is represented by $\begin{smallmatrix}o&o&\\o&o&o\\o&&o\end{smallmatrix}$, B by $\begin{smallmatrix}o&&o&o&o\\o&o&o&o&o\\&o&o&o&o\end{smallmatrix}$, C by $\begin{smallmatrix}o&&o&o&&o\\o&o&o&o&o&o\\&o&o&&o&o\end{smallmatrix}$, D by $\begin{smallmatrix}o&&o&o\\o&o&o&o\\&o&o&o\end{smallmatrix}$, and so on through the alphabet. A number of specimens of the alphabet will be punched off, and any one in the room desiring a specimen, will be able to obtain one at the close of the lecture. The paper so punched is used to regulate machinery on exactly the same principle that is used in the Jacquard loom. A clerk can punch at the rate of 45 words a minute, but the average is 40 words a minute.

Practically, the number of punchers is unlimited, as the transmitter will run the slip as fast as the wire will convey the messages. As a rule, on the busiest circuits, three punchers are employed. I have known as many as six punchers employed at

the same time, but the average number may be taken at two, and the average rate of each, 40 words a minute. The punched paper passes through the transmitter. There are two transmitters, and to show their action I will just pass an alphabet through one of them. The transmitter in connection with the Bain instrument is now running, at a slow rate, and you will see the signals being slowly recoiled by the receiver on a paper slip, which has been prepared with iodide of potassium. I will now set the transmitter at a more rapid rate and you will see how quickly the signals are transmitted. The slip is now running at the rate of about 120 words a minute. How is it that this punched paper slip, with its series of dots and dashes, can so regulate a piece of delicate machinery like that as to make it send and record dots and dashes in this manner at such a rate? The principle is shown on the diagram (Fig. 11). I have before mentioned how extremely difficult it is to render diagrams of intricate apparatus comprehensible to an audience. It is always better for any one who wishes to understand how an apparatus works, to examine it himself, to make himself acquainted with its principle, and examine the actual mechanism itself.

The principle of the transmitter is nearly identical in all kinds. There is an ebonite working lever, in which two brass pins are inserted. One of these pins is connected by a fine wire to the line, and another is similarly connected with the earth. This lever rocks with a backward and forward motion with tremendous velocity, and as it rocks it causes the two rods (one marked A and the other marked B) to move up and down in the same way with the velocity of the ebonite lever. Also there are two crank levers, one attached to the zinc of the battery, and the other attached to the copper

Fig. 11.



WHEATSTONE'S AUTOMATIC SYSTEM

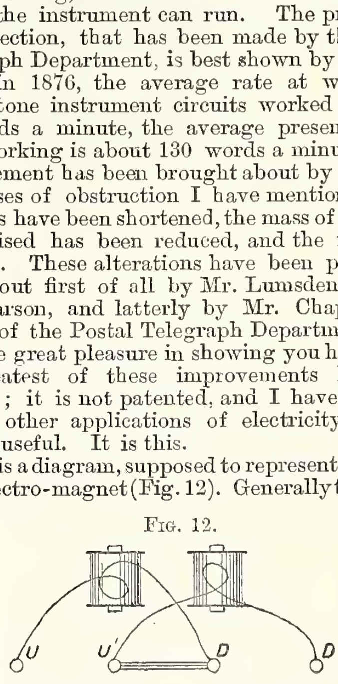
of the battery, which are pressed towards each other by springs (C and D). The rods A and B, that work vertically up and down, are also attached to similar levers, and are pulled by two springs, which always cause them to tend upwards. As the lever rocks, these two rods move up and down, and so long as the paper, E, passes over them without any perforation or hole in it, so the rocking harmlessly continues, that is, it causes no current whatever to flow to line; but if immediately over the needle, B, a hole be placed, then that needle in its upward motion passes through the hole and causes the copper pole of the battery to go to line; the zinc pole of the battery being connected to earth, and a current is transmitted to the distant station. That is the case when the top hole is punched. If the bottom hole be the one punched, then needle A passes through it, and in doing so (the reverse of what I have just explained takes place, and) a zinc current goes to line, and a copper to earth. So that we see when the needle B passes through the top hole a copper current goes to line, and when needle A passes through the bottom hole a zinc current goes to line. These currents are momentary, and whenever they pass, a dot or dash is simply made by the rate at which one current follows the other. If first of all a positive current be sent, and then a negative current immediately after it, we have a dot; if we send a positive and that is followed by a blank, then by another blank, and then by a negative current, we have a dash; so that the difference between a dot and dash is due to the loss of a current. If all the holes were punched without a space you would have a succession of rapid reversals sent to line—positive, negative; positive, negative; and so on, one repeated after the other. The reversals in this system are not made in the same way as I have explained to you in other apparatuses, by the duration of the current itself, but they are made really by pauses and the practical absence of current. The way in which this reversal works will be more evident to you when I explain the receiver; for the present I only want you to notice that the first part of the dot is produced by a positive current, the last by a negative current following immediately. The first portion of the dash is made by a positive current, then a hiatus, followed by a negative current (positive, negative the same as before), and the result is that by sending the paper through, punched in this way, we regulate the rate at which the rocking lever, or rather we do not regulate the rocking lever, for that goes at a constant speed; but we regulate the number of times that the needles pass through their holes, and so regulate the formation of dots and dashes at the distant station. By this means we are able to send dots and dashes with marvellous rapidity. We will now put a slip through this other transmitter. That slip is going through at the rate of

140 words a minute. One slip can be used almost any number of times. The punched paper, as it passes through the transmitter, causes the little vibrating rods to select their proper holes, and to regulate the positive and negative currents as they pass to line. The positive current acts upon what is practically a relay, and causes the tongue of that relay to move over to one side. The negative current immediately following causes the tongue to go back to the other side. A dot is made by a rapid reversal; a dash is made by two reversals, the middle one being missed. This action is shown by the diagrams, but will be more clear to you when you see the instrument actually at work. The positive and negative currents having passed through the transmitter to line, arrive at the distant station, and act upon the receiver. The receiver is really nothing more nor less than an extremely delicate form of ink-writer, based on the Morse principle, and is so constructed that it records the message at considerable velocity. There are two things necessary to make a receiver of this kind work well. The first is that, running at the very high speed requisite to receive the signals with such velocity, the mechanism must be so perfect that it shall not lose its regularity, but run in accordance with the rate at which the messages arrive. Secondly, the mechanism must be supplied with a governor, and a very great amount of ingenuity has been displayed in the formation of governors to those delicate machines. Attached to this receiver we have a governor, that can regulate the speed from about 20 to 200 words a minute. The ordinary forms of receivers only go to 130 words a minute, but the necessity of the age and growth of business have compelled us to look ahead a little, and now we have instruments constructed so that they can be regulated up to a speed of 200 words a minute. Again, the action of the receiver depends essentially upon the electro-magnetic part of the apparatus. I have mentioned once or twice that one of the chief difficulties we have to contend with in telegraphs is due to the existence of a disturbance on the line, called electrostatic induction, which is, as I mentioned to you, something like friction in pipes. It retards the currents, and causes the positive and negative currents sent with great rapidity to run into each other and to record their marks slowly. The speed at which the instruments receive the messages is governed a great deal by the resistance opposed to the passage of the currents. The greater the resistance, the less the strength of current flowing, and the slower the rate at which the instrument works. But there is a very curious cause of retardation or disturbance of these instruments, due to what is called the electro-magnetic inertia of the electro-magnet itself. Wherever a current is sent round an electro-magnet, another current is set up in that electro-magnet in the opposite direction, and this "extra" current, as Faraday calls it (it is one of Faraday's greatest discoveries), opposes the strength of the first current, and, therefore, produces retardation. So that, in the working of these fast speed apparatus, we have to overcome resistance, electrostatic induction, and electro-magnetic inertia. These are points that have been attacked, within the last few years, by the officers of the Postal Telegraph Department, with a great amount of zeal and ingenuity, and one by one they have been mastered until now, instead of being able to work only at the rate of 45 words a minute on the Morse, we can work, say, 150 words a minute; which is practically as fast as we want to work anywhere. In 1876, for instance, the rate at which one of the best wires in the country was worked was 120 words a minute, that is, to Manchester. To Sunderland, the rate was 90; to Aberdeen, the rate was 60; to Dublin, the rate was only 40; and to Cork (one of the longest circuits we have), the rate of working by this automatic apparatus was then only 38 words a minute. By removing the disturbances I have mentioned, we are now able to work to every one of these stations as fast as the apparatus will run, and to Cork (I took the trouble this morning to find out the rate) we are working daily at the rate of 130 words a minute. That is simply the rate at which the instrument works, and not the rate at which it can work; and if apparatus of the newest pattern be used, and if there be a necessity (which, probably, there will be in a year or two) to increase the rate of working, I have no doubt we shall work to Cork at the rate of 200 words a minute. Now, the amount of business does not require a greater speed then we are working at, and from 1,000 to 1,200 messages are transmitted daily between London and Cork, through a wire fitted with this automatic apparatus. The rate of working to Aberdeen is another instance of fast speed transmission. The wire from London to Aberdeen is 600 miles long, and over this wire we can work as fast as the instrument can run. The progress in this direction, that has been made by the Postal Telegraph Department, is best shown by this, that while, in 1876, the average rate at which our Wheatstone instrument circuits worked was only 70 words a minute, the average present rate of such working is about 130 words a minute. This improvement has been brought about by attacking the causes of obstruction I have mentioned. The magnets have been shortened, the mass of iron to be magnetised has been reduced, and the resistance lowered. These alterations have been principally carried out first of all by Mr. Lumsden, next by Mr. Marson, and latterly by Mr. Chapman, all officers of the Postal Telegraph Department.

I have great pleasure in showing you how one of the greatest of these improvements has been effected; it is not patented, and I have no doubt that in other applications of electricity the idea may be useful. It is this.

Here is a diagram, supposed to represent two cores of an electro-magnet (Fig. 12). Generally the wire of

Fig. 12.



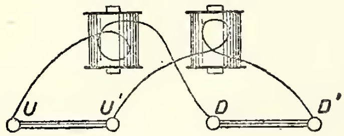
SINGLE WOUND SERIES

an electro-magnet passes round it a great many times, but in the diagram one spiral only is shown. In this diagram the wire shows the manner in which a magnet is ordinarily wound, and is said to be

wound in series, the current entering at the left and passing out at the right. In a magnet so wound we have what is called an extra current, and this extra current, as I have described to you, produces retardation.

The first improvement in this magnet was effected by joining the electro-magnet up in what is called "quantity" (Fig. 13). The current in pass-

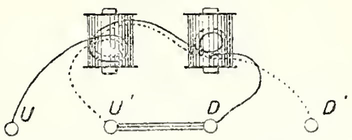
Fig. 13.



SINGLE WOUND QUANTITY

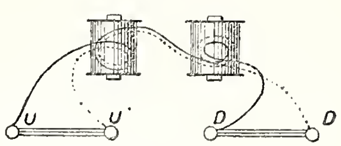
ing through an electro-magnet so joined up divides itself, one-half going through the right coil and the other half going through the left coil, and the first effect of this was to reduce the resistance of the coil. But it had another and curious effect, and that was that the extra current in the left leg met the extra current in the right leg, and they neutralised each other, and this removal of the extra current considerably expedited the working speed of the electro-magnet. The next improvement was that as duplex telegraphy became introduced, all our apparatus, whether worked as duplex or not, were wound "differentially," as it is called, so as to be available for duplex working at any time; and the coils shown by this diagram (Fig. 14), are supposed to represent a magnet, such as we have on the receiver before you, and are wound differentially. A current starting from U passes through the whole course of the wire and meets all the resistance of the circuit before it arrives at D'. To reduce this resistance, the coils, as I have said, are joined up in quantity (Fig. 15). [Course of current through quantity arrangement described.] The quantity arrangement reduces the resistance by three-fourths. But lately we have joined the coils up in "double quantity," as it is called, as shown in diagram (Fig. 16).

Fig. 14.



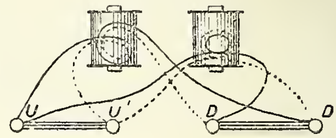
DOUBLE WOUND SERIES

Fig. 15.



DOUBLE WOUND QUANTITY

Fig. 16.



DOUBLE WOUND DOUBLE QUANTITY

[Course of current through double quantity arrangement described.]

The "double quantity" not only reduces the resistance still further, but the extra currents in each coil are completely neutralised by the extra currents in the other coil, and they are entirely prevented from producing a retarding effect. Many other means of improvement, such as shunts, condensers, strong batteries of low resistance, and high electro-motive force, and others that I have not time to allude to, have been employed, with the result that we have attained this great accession of speed. But a great accession of speed has also been obtained by another and quite different manner. Take, for instance, a wire from London to Cork. The first portion of the wire extends on poles from London to Haverfordwest, about 300 miles; from near Haverfordwest (Abermawr) to Wexford it passes through a cable, about 80 miles; and from Wexford to Cork we have about 100 miles on open poles. The principal cause of delay in working this wire is the existence of a cable in the middle of its path, just at the point where it opposes to the working of the circuit the maximum amount of electro-static induction. The rate at which such a circuit works is governed by the speed at which its cable section works. It is quite possible to make an open-air line between London and Haverfordwest work a great deal faster than the cable between Haverfordwest and Wexford. The addition of cables to open lines is simply to retard the working, and we find that if it were possible to introduce at the end of the cable a translator, or relay, which would bring into play fresh currents, the speed of working would be very much increased. This was tried, and we found that while the wire had only been working at the rate of about 40 words a minute previously, when a relay was put in at Haverfordwest, the speed at once jumped to something like 100 words a minute, and the success of this mode of working was so satisfactory that a relay was speedily placed on the London-Jersey circuit, the speed of which was at once improved from about 50 to 80 words a minute, and so on. The success of inserting fast speed translators in the middle of our lines has become so great and so evident, that at the present moment, we have no less than 50 of these translaters fixed in different parts of the country; and these have aided materially in producing the great accession of speed I mentioned just now. For instance, between London and Aberdeen we have a translator fixed at Newcastle. Without that translator the wire would not work at a greater speed, probably, than 80 words a minute,

but with it we get 140. Again, between London and Dublin, we have established a relay station in Anglesea, and the result has been to make the rate at which we work to Dublin practically unlimited. And of all the improvements that have been introduced into the postal telegraph service, there perhaps is none more important than that of introducing these translator-relays. The amount of business transacted by these long circuits is something fabulous. There is not a single town in this country which possesses a daily paper that has not direct communication with London by means of these wires; and every morning at the breakfast table, everybody wherever he may be, is able to get the whole news of the country, which has been transmitted by means of these wires. In fact, the news system is quite a system of its own. A wire running to the West supplies news to Bristol, Exeter, Plymouth, Gloucester, Newport, and Cardiff, and all those six towns receive simultaneously, on Wheatstone receivers, news that is punched on one slip in London. It is only necessary to punch one slip, which can be run through a transmitter on one wire, and supply all the towns on that wire that receive the same news, and can then be run through another transmitter, and supply other towns to which the same news is furnished; so that thirty or forty, or almost any number of towns, can, by this means, be supplied from one slip.

The limit of working has not yet been reached. It is quite possible (though the necessity for it has not yet arisen) to duplex this Wheatstone automatic apparatus. I do not say that, in duplexing, we shall be able to secure on these long circuits double the speed; but there is no doubt that, in duplexing, we shall very much increase the capacity of the wire. At the present moment we do not want to send more than 150 words a minute, but I have not the least doubt that, when the time comes, with our present apparatus and our present knowledge, we shall be able to transmit, at least, 300 words a minute.

There are in the country, now working, 250 of these transmitters, and 370 receivers; they are all worked at very high speed.

I think I have said enough to show you that the improvements that have been effected, have simply arisen from the necessity of the day. Requirement always brings forth the exertion of zeal, thought, and experience, and all the improvements that have been made, especially those instanced in the apparatus now before you, are the result of this experience.

While the ancients devoted their time principally to questions of philosophy and art, the men of the present day—the moderns—devote their time principally to questions of industry and the application of mechanics to the wants and purposes of man. The growth of all telegraphic apparatus has been growth by evolution. The apparatus which you see before you is in reality the survival of the fittest. We commenced by using the very crude instruments which I described to you in previous lectures—the double and single needles; we have now come to the employment of perhaps the most delicate piece of mechanism to be found in any trade. I do not think I am wrong in saying that in no art will you find more beautiful, carefully constructed, or elegantly designed mechanism employed than in the instrument before you; and for its production I can tell you that we are chiefly indebted to that prince of mechanicians, Mr. Stroh. All the improvements, as I told you, have been the result of experience, patience, and trial, and if you could only see the patience which some of our electricians of the Post-office work out these trifles, you would be surprised that there are men who devote their time in such a way. But this process is always going on; it is constant and incessant, and improvement keeps pace with the requirements of the day.

There has rarely arisen a necessity of any kind, but that somebody has stepped forward to meet it, and when we hear people say that invention has left the shores of England and gone to other climes—why those who say so cannot pay any attention to what is going on about them, and if they entertained that thought for a moment, they would find it upset at once if they but only saw for themselves the great progress made in this country.

The main object of my lectures has been to try and show you that we are not idle at home, and to try and show you that whatever may be the requirements of this country, as far as speed, capacity, and rapidity are concerned, we have, in your own public service, men who are determined to carry out as, far as their ability will allow them (and who, I really believe, are competent to do so), all the necessities and requirements of the age.

At the conclusion of the lecture (the last of the course), the **Chairman** (Mr. F. J. Bramwell) made the following remarks:—Ladies and Gentlemen,—Before you leave this room, I beg that you will return your hearty vote of thanks to Mr. Preece for his course of Cantor Lectures. I am sure you will agree with me that the lectures have been most interesting and enjoyable; and though Mr. Preece says he has not been very happy while rendering them, I should have liked him to have been unhappy a little longer, and given us a few more evenings of enjoyment, which is enjoyment of the best kind, because it calls upon us to exercise all our intelligence in following out the wonderful improvements Mr. Preece has so lucidly brought before us. There are three kinds of lecturers. The first is the man who thinks he understands what he is talking about, but does not; the second, the man who does understand his subject, but cannot explain it; the third, and rarest of all, is the man who understands everything he is talking about thoroughly and completely, and can yet, at the same time, bring himself to consider that there are others who have not yet got his knowledge, and who can so describe his subject to them as to make them almost equally thoroughly understand it. Mr. Preece is one of the third class of lecturers, who, knowing the matter that he has to deal with thoroughly, can, nevertheless, bring himself down to the level of those approaching it for the first time, and send his audience away in the happy consciousness of having been instructed in such a manner as to make them capable of taking their knowledge home, and retain it. There are different ways of explaining things. Some can explain in such a manner as to enable their listeners to at once grasp and take hold of the idea, while others, after what they consider a thorough explanation of the subject, leave their listeners in such a frame of mind that they could scarcely repeat any portion of it. Any one who has listened to Mr. Preece to-night cannot fail to clearly understand the matter. I have not heard the other lectures Mr. Preece has delivered before you. The loss is mine, but I am perfectly certain that throughout the course he has

thoroughly brought the subject before the audience; and, without detaining you further, I will ask you to return your hearty vote of thanks to Mr. Preece for the lectures.

Mr. Preece—Mr. Chairman,—There are always two things necessary in every lecture. The first is the lecturer; the next is the audience; and the success of a lecturer always depends upon his audience; and, sir, I can only say that, if you had been here as often as I have, you would agree with me when I say that I could not have had a more appreciative audience.

OBITUARY.

Charles Lewis Gruneisen, for many years the musical critic of the *Athenæum* journal, died on Saturday, the 1st instant, at his house in Surrey-street, Strand. Dr. Gruneisen was elected a member of the Society of Arts in the year 1860. He was an active member of several musical committees, and an occasional contributor to the *Journal*. Born in November, 1806, he early became connected with the press. In 1838 he represented the *Morning Post* during the Carlist war, and, being taken prisoner, he nearly escaped execution as a spy. A few years later, on the occasion of the visit of the Queen and the late Prince Consort to Louis Philippe, he was highly successful in obtaining early news for the *Post*, of which he was then Paris correspondent, and in those pre-telegraphic days he organised a system of despatch by means of carrier pigeons. During his stay in Spain, Dr. Gruneisen made a special study of the popular tunes of the country, and ultimately he confined himself to musical criticism. He was one of the chief promoters of the Royal Italian Opera which was opened at Covent Garden Theatre in 1847. He was also one of the founders of the Conservative Land Society, and became its secretary in 1853. This office he held until 1872.

GENERAL NOTES.

Production of Clocks and Watches.—The following statistics with regard to the manufacture of clocks and watches are furnished by "Galignani's Messenger." France is placed at the head of the list, and is credited with the production of chronometers, watches, timepieces, and clocks annually to the value of 65,000,000 francs; then comes Switzerland, with watches, 60,000,000 francs; America, watches and clocks, 32,000,000 francs; England, chronometers and watches, 16,000,000 francs; Austria, timepieces, 10,000,000 francs: Germany, timepieces and watches, 25,000,000 francs. This gives a total considerably over 200,000,000 francs for the whole watch and clockmaking trade in the world. The amount assumes the greater importance when the fact is remarked that, differing from nearly all other businesses, the raw material enters so slightly into the prime cost; the principal expenditure being almost exclusively in labour. The approximate number of articles produced is as follows:—France about 1,000,000 pieces annually; Germany turns out about 2,000,000 of an inferior article. The same may be said of the American manufacture, which turns out from 700,000 to 800,000. As far as watches are concerned, Switzerland heads the list with an annual production of 1,500,000; France follows with 500,000; United States from 300,000 to 350,000; England 200,000, but these are of very superior quality. The enormous total is that 2,500,000 watches and 4,000,000 timepieces are annually dispersed in the four quarters of the globe.

Yorkshire College.—The calendar of the college for the sixth session (1879-1880) has been lately issued. The department of textile industries continues to receive special attention, and, although the students cannot be accommodated in their new premises at Beech-grove at the opening of the session, as had been hoped, their interests have been amply provided for in the temporary class-rooms and in the weaving annexe in Cookridge-street. As an inducement to students who have gone through the first-year course of weaving and designing, &c., to perfect their studies, they are to be allowed, on entering the second-year course, the gratuitous use of the various appliances in the weaving annexe on days when they are not attending the ordinary class instruction. By this arrangement a student may, if he pleases, spend four days in the week at the college, at designing, card cutting, hand and power-loom weaving, and in other matters connected with the textile education. Arrangements for the establishment of a school of dyeing are in an advanced state, but, as the new dye-house cannot be got ready until the beginning of 1880, the work of instruction in this important branch of technical education has to be deferred for a few months. A special syllabus of the course for dyers is to be published as soon as the arrangements have been completed. In the evening classes, which are open to those who are not enrolled students, there are to be courses of lectures on mechanics, chemistry, geology, biology, botany, and engineering, and classes in Latin, Greek, English grammar, and textile industries.

NOTICES.

THE LIBRARY.

The following works have been presented to the Library:—

Charter, Bye-laws, and Regulations of the Institution of Civil Engineers. (London: 1879.) Presented by the Institution.

The Model Locomotive Engineer, Fireman, and Engine-boy, by Michael Reynolds. (London: Crosby Lockwood and Co., 1879.)

The Saidapet Experimental Farm Manual and Guide, prepared, under the orders of Government, by Charles Benson. (Madras: 1879.)

Color-blindness; its Dangers and its Detection, by B. Joy Jeffries, A.M., M.D. (Boston: Houghton, Osgood and Co., 1879.) Presented by Trübner & Co.

Transactions of the Institution of Naval Architects. Vol. 20. (London: 1879.) Presented by the Institution.

Luxurious Bathing: a Sketch by Andrew W. Tuer, with 12 folio etchings, &c., by Sutton Sharpe. (London: Field and Tuer, 1879.) Presented by W. Tuer.

Journal of the Royal Geographical Society. Vol. 48. (London: John Murray.) Presented by the Society.

Transactions of the Institution of Engineers and Shipbuilders in Scotland. Vol. 22. (Glasgow: 1879.) Presented by the Society.

MEETINGS FOR THE ENSUING WEEK.

Mon., Nov. 10...Institute of Surveyors, 12, Great George-street, S.W., 8 p.m. Opening Address by the President, Mr. William Sturge.
Royal Geographical, University of London, Burlington-gardens, W., 8.30 p.m.

Tues., Nov. 11...Metropolitan Scientific Association, 13, Blomfield-street, Finsbury-circus, E.C., 7 p.m.
Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Discussion upon Mr. Blandy's paper on "Dock Gates."
Photographic, 5A, Pall-mall East, S.W., 8 p.m.

Wed., Nov. 12...Society for the Development of the Science of Education, Memorial-hall, Farringdon-street, E.C., 7.30 p.m. Mr. W. Graham, "Imagination."
Royal Microscopical, King's College, W.C., 8 p.m.
Society of Telegraph Engineers, 25, Great George-street, S.W., 7 p.m. Mr. J. R. Preece, "The Telegraph from Teheran to Bushire."

JOURNAL OF THE SOCIETY OF ARTS.

No. 1,408. Vol. XXVII.

FRIDAY, NOVEMBER 14, 1879.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

PROCEEDINGS OF THE SOCIETY.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One-Hundred-and Twenty-sixth Session of the Society will be held on Wednesday, the 19th inst., when the Opening Address will be delivered by Lord ALFRED S. CHURCHILL, Chairman of the Council. Previous to Christmas there will be Four Ordinary Meetings, in addition to the Opening Meeting.

Candidates proposed for election as members are privileged to attend the Opening Meeting.

ORDINARY MEETING.

The following arrangements for the Wednesday evenings before Christmas have been made:—

NOVEMBER 19.—Opening Meeting of the Session. Address by Lord ALFRED S. CHURCHILL, Chairman of the Council.

NOVEMBER 26.—"Suggestions for dealing with the Sewage of London." By Major-General H. Y. D. SCOTT, C.B., F.R.S.

DECEMBER 3.—"Apprenticeship: Scientific and Unscientific." By SILVANUS P. THOMPSON, B.A., D.Sc., Professor of Experimental Physics at University College, Bristol.

DECEMBER 10.—"Art Vestiges in Afghanistan; the Result of Some Recent Explorations in the Jellalabad Valley." By WILLIAM SIMPSON.

DECEMBER 17.—"The Panama Canal." By Captain BEDFORD PIM, R.N., M.P.

At the meetings after Christmas the following papers, amongst others, will be read:—

"Domestic Poisons." By HENRY CARR.

"Gas Furnaces and Kilns for Burning Pottery." By HERBERT GUTHRIE, C.E.

"The Utilisation of Slag." By CHARLES WOOD.

"Art in Japan." By C. PFOUNDES.

"The Trade and Commerce of the Yenisei." By HENRY SEEBOHM.

"Modern Autographic Printing Processes." By THOMAS BOLAS, F.C.S.

"The History of the Art of Bookbinding." By HENRY B. WHEATLEY, F.S.A.

"Art Ironwork." By J. W. SINGER.

"The History of Musical Pitch." By A. J. ELLIS, F.R.S.

"The Recent History of Explosive Agents." By Prof. F. A. ABEL, C.B., F.R.S.

"Iceland and its Resources." By C. G. W. LOCK.

"The Future of Epping Forest." By WILLIAM PAUL, F.L.S.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday Evenings, at eight o'clock:—

February 3, 24; March 16; April 6, 27; May 18.

CHEMICAL SECTION.

The meetings of this Section will take place on the following Thursday Evenings, at eight o'clock:—

January 22; February 12; March 11; April 8, 22 May 13.

INDIAN SECTION.

The meetings of this Section will take place on the following Friday Evenings, at eight o'clock:—

January 30; February 20; March 5; April 2, 16; May 7.

CANTOR LECTURES.

The First Course of Cantor Lectures will be delivered by Dr. CHARLES GRAHAM, F.C.S., F.I.C., Professor of Chemical Technology at University College, London, on "The Chemistry of Bread and Bread-making."

The Second Course will be on the "Manufacture of India-rubber and Gutta-percha," by Mr. THOMAS BOLAS, F.C.S.

The Third Course will be by Mr. R. W. EDIS, F.S.A., on "Art Decoration and Furniture."

Syllabus of the First Course.

LECTURE I.—Introduction. Chemical composition of the chief bread-stuffs. The chief properties of starch, dextrin, starch sugars.

LECTURE II.—Continuation of the examination of starch and its hydration products. The albuminous matter of flour, soluble and insoluble.

LECTURE III.—Action of albuminoids. Rationale of kiln drying. Flour making. The dough. Action of moisture, heat, and albuminoids on starch.

LECTURE IV. — Fermentation. Leaven. Yeast. Ferments of disease. Changes produced. The use of the microscope in the examination of yeast.

LECTURE V.—Baking; changes produced by heat. Aërated breads; foreign breads; biscuits, &c. Digestion of bread a continuance of fermentation; conditions requisite. Conclusion.

JUVENILE LECTURES.

The usual short course of lectures adapted for a juvenile audience will be given by Mr. W. H. PREECE on "Wonders of Sound" and "Wonders of Light." The dates for the lectures will be the 30th December and the 6th January. The lectures will commence at seven o'clock. Special tickets will be issued for these lectures.

ADMISSION TO MEETINGS.

Members have the right of attending all the Society's meetings and lectures. They require no tickets (except for the Juvenile Lectures), but are

admitted on signing their names. Every Member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor Lectures. Books of tickets for the purpose have been issued to the Members, but admission can also be obtained on the personal introduction of a Member.

Annual General Meeting.

The Annual General Meeting will be held on June 23rd, at four o'clock.

Evening Meetings of the Society will be held on the following dates, subject to any alteration which may be found necessary:—

	CANTOR LECTURES.	FOREIGN AND COLONIAL MEETINGS.	ORDINARY MEETINGS.	CHEMICAL MEETINGS.	INDIAN MEETINGS.
	Monday.	**Tuesday.**	**Wednesday.**	**Thursday.**	**Friday.**
1879.					
November	— — — 24	— — — —	— — 19 26 —	— — — —	— — — —
December	1 8 15 22	— — — —	3 10 17 — —	— — — —	— — — —
1880.					
January	— — — —	— — — —	— 14 21 28 —	— — 22 —	— — — 30
February	2 9 16 23	3 — — 24	4 11 18 25 —	— 12 — —	— — 20 —
March	1 8 — —	— — 16 —	3 10 17 — —	— 11 — —	5 — — —
April	5 12 19 26	6 — — 27	7 14 21 28 —	8 — 22 —	2 — 16 —
May	3 10 — —	— — 18 —	5 12 19 26 —	— 13 — —	7 — — —

The Chair will be taken at Eight o'clock at each of the above Meetings.

PARIS EXHIBITION.—ARTISAN REPORTS.

The selected Reports on the Paris Exhibition, made by the artisans who were sent out last year by the Society of Arts, have now been published by Messrs. Sampson Low and Co.

The price of the volume is 7s. 6d. Members of the Society of Arts, and Exhibitors at the Paris Exhibition, will be charged 5s. 8d.

Besides being published in a single volume, the reports have been issued in 11 divisions, making 12 parts in all, viz.:—

1. { Pottery and Glass. Part I. (4 reports.)
   Pottery and Glass. Part II. (2 reports.)
2. Art Workmanship. (5 reports.)
3. Mechanical Engineering (4 reports.)
4. Agriculture and Horticulture. (3 reports.)
5. Building Trades. (5 reports.)
6. Cabinet Work. (3 reports.)
7. Watch and Clock-making, Jewellery, and Optical Instruments. (4 reports.)
8. Printing. (2 reports.)
9. Textile Fabrics. (2 reports.)
10. Leather and India-rubber. (3 reports.)
11. Mining and Metallurgy. (2 reports.)

In the hope that these parts may prove acceptable and serviceable to the classes interested in each particular industry, they have been issued at the price of 6d. each. Twelve copies of any of the parts will be supplied at 4s. 6d.

Messrs. Jackson and Sons, of Rathbone-place, write to draw attention to the fact that they were the exhibitors of the collection of samples of plaster work, referred to in the report on that subject, and not Messrs. Jackson and Graham, as was stated in error in the report. The mistake occurs on page 361 of the published volume. Unfortunately, it is too late to make the correction in the volume itself, but Members who have purchased copies are requested to make the alteration for themselves.

MATIONAL CULTIVATION OF MUSIC.

The First Report on establishing Local Schools of Music, and Teaching Music by Notes in Public Elementary Schools, is now published, and may be obtained from the Society by transmitting one shilling in postage stamps to the Secretary, John-street, Adelphi, London, W.C.

NATIONAL TRAINING SCHOOL FOR MUSIC.

In consequence of the numerous applications from the public for admission, the Committee of Management of the National Training School for Music have made arrangements to receive private pupils for periods of not less than one year, on the payment of fees. Such pupils will be required:—

1. To pass a test examination to the satisfaction of the principal of the Board of Professors.

2. To furnish the authorities of the school with certificates of birth and health, and with testimonials from persons of good repute as to moral character.

3. To pay, in advance, to the bankers of the school, Messrs. Coutts & Co., Strand, the sum of £40 per annum.

4. To sign an agreement to observe all the rules of the school, and to work out the curriculum of studies appointed by the authorities of the school.

Applications and inquiries should be addressed to the Registrar, National Training School for Music, Kensington-gore, S.W.

MISCELLANEOUS.

PHYSICAL TRAINING AT SCHOOLS.

Mr. E. Chadwick, C.B., delivered an address before the Sanitary Institute, at Anerley, on Saturday, 25th inst., on the "Norma of Sanitation, in the School Stages of Life, chiefly on the Half-Time Principle of Mixed Physical and Mental Training, as displayed at the North Surrey District Orphanage Institution, at Anerley," in which he observed:—

"We have to deal with conditions in populous districts, in which half of all who are born are dead within their fifth year. In London, which, by those who have yet to be largely instructed as to sanitary power and principle, is boasted of as the healthiest city in the world, there are districts where about half of all born of the lower class are in their graves by the sixth year. On an examination, a few years since, it appeared that the excess of deaths in the school stages of life throughout England and Wales amounted to upwards of 50,000 annually. Now, we have to deal specially with the causes of such excess. The common conditions of epidemic in the school stages of life are those in which children with filthy skins and filthy clothes are massed together, and kept together in sedentary constraint, during long hours. This institution supplies a normal example, happily with others, of the results generally obtainable by the removal of these conditions.

"I can only advert shortly to one great topic, of the moral progress which accompanies correct sanitary and physical progress. An instance of the disorder arising from physical causes in the common training of children, may be presented from an instance of an interruption of progress in this institution. A former managing committee agreed that the military drill—the chief available mode of physical training—was unnecessary, and they dismissed the drill-master. The immediate result of the deficiency of bodily exercise was bodily irritability, and thence uncontrollable mental irritability on the part of the boys;—there were tumults and bolstering in the dormitories, breaking of windows, chamber utensils, and all sorts of riot and disorder ensued. In less than a fortnight, as was stated to me, damage was done to the amount of more than two hundred pounds—more than three years' salary of the drill-master. The chaplain exhorted and prayed; the masters flogged, and flogged, and flogged; but without effect, as it did not touch the seat of the depravity—the irritation from the deficiency of physical exercise. At last, the chaplain and the manager besought the restoration of the drill-master and the physical exercise he directed. This was done. There was satiety of the demands of physiology, there was quiet sleep in the dormitories, and so it has gone on.

"The half-school time principle of instruction, which when properly conducted, involves simultaneous class-teaching, is to be credited with a large reduction of school irritation, even during the reduced school time Including the infant-school teaching, the children on the half-time system attain, by the tenth or eleventh year, results as good, or better, than are attained in the common national or voluntary, or long-time Board-schools two years later, at a cost of less than one pound per head per annum of the children taught, or less than one-half the cost of the London School Board.

"To conclude for this occasion. It has been accepted as a general proposition, that disease is generated by massing large numbers together; that is to say, in ordinary conditions, and in those conditions the proposition is doubtless true. But the working of this institution, with others on the half-time principle, with the light of sanitary science, 'massing numbers together' is proved to be a great preventive of epidemics, and a means of reducing sickness and mortality to the lowest point of which we have known examples. In education it is held that 'massing children together in large numbers' is detrimental to them morally; and that teaching—meaning popular elementary teaching—in small schools is the best. And this is commonly so where large numbers are massed together, and kept together during long hours of sedentary constraint, in violation of the laws of physiology, under exactions of mental tasks beyond the children's powers of mental receptivity. But where the half-time principle is properly understood and applied, as it has been in this institution, with simultaneous class teaching, the highest results are produced in morals and intelligence for productive occupation, as tested by the outcome."

THE INDIA MUSEUM.

At the meeting of the India Council on Tuesday, a final decision was come to regarding the disposal of the India Museum. We may at once say that the museum does not cease to exist, and that it will, in the course of six or seven months, be re-opened, with additions which will present to the people of this country such an exhibition of the manufacturing and artistic resources of India as has never before been laid open to their view. And, beyond this, most important and self-contained collectious in illustration of the Indian building art of antiquity, and of the economic mineral, vegetable, and animal productions of India, will at once be established at the great centres of learned and scientific research, and of industry and commerce, in the United Kingdom. In coming to the determination that Indian revenues should no longer be burdened with the charge of keeping up in London an Indian Museum, the Secretary of State in Council recorded his opinion that the special character and utility of the museum should be maintained unimpaired. One of the direct objects of the arrangements which have been concluded for its disposal was to increase the value of the museum for the specific official purposes for which it exists. The museum has grown up out of the constant applications from the local Governments for information regarding the market value of indigenous economic articles unknown in general commerce, and also regarding the productions of other countries which might be adapted for naturalisation in India, and the specimens which have thus been amassed really constitute the India Museum as an official reference collection. This collection has now been intrusted to the authorities at Kew. A grant of £2,000 has been made for the enlargement of the Kew Museum on that account, and a small annual sum will be allowed for contingent expenses and to secure the services of an expert cryptogamist in connection with the collection. In its economic section the India Museum was little more than a very costly duplicate of Kew, which it could never approach in encyclopædic completeness, and it will necessarily be of incalculable benefit to the India-office to keep its economic collections for the future at Kew, where they will be in charge of the first English botanists. In fact, the Indian Secretary will now always have the assurance that the reports on Indian products forwarded by him to the local Governments in India have not only been carefully prepared by his own officers, but are supported by the best scientific advice in this country. Moreover, the Kew authorities, in continuation of a scheme set on foot by Dr. Forbes Watson, the late Reporter on Products, have undertaken to supply out of their surplus stores samples of Indian articles, to any museums in our larger manufacturing and commercial towns, which will undertake the cost of suitably exhibiting them to the public. It cannot but be admitted, therefore, that the interests

of India will be promoted in every way by the terms which have been concluded with Kew. As to the zoological collection, it has been always understood that it would be transferred to the British Museum on the completion by the trustees of their new Natural History Museum at South Kensington, and the propriety of this arrangement has never been questioned. The Buddhistic sculptures will also be taken by the British Museum, where they will fill up a gap in the imposing chronological series of the remains of ancient art already in the possession of the trustees. The Amravati, Sanchi, and other Buddhistic sculptures will probably for the first time be rightly appreciated when ranged in order with those from Babylonia, Assyria, Egypt, Asia Minor, Greece, and Italy, and the visitor will have the opportunity of comparing at a glance the carved lions of Mycenæ, Nineveh, and Bharhut. It was stated the other day in the *Times* that the whole of the sculptures remaining at Amravati were now in the India Museum, but we have since learnt that, owing to the exertions of Mr. Robert Sewell, assistant collector in the Godavery district, more than twice as many sculptures as are at the India Museum have been lately unearthed by him *in situ* at Amravati, and we are glad to be able to announce the prospect of their being speedily transported to this country. Casts of all the sculptures taken by the British Museum will be prepared for the South Kensington Museum, to complete its series in illustration of Indian architecture; and South Kensington will also receive the whole of the India Museum collections of ethnography and arts and manufactures, which make up the museum as popularly understood, and stamp its speciality. These collections will be kept together as they are and where they are, with the addition to all the Indian collections at present in the South Kensington Museum, and of private collections which have been already offered on loan. When the lower India Museum galleries are re-arranged with full-sized casts of the different building styles of Buddhistic, Brahminical, and Mogul India, and the upper galleries are crowded with the richest examples of the sumptuary arts of India, the revived India Museum will vie in splendour even with the sister museum of European art on the opposite side of the road at South Kensington. It will present an unrivalled collection of Indian pottery; wood, ivory, horn, and stone carvings; brass, copper, iron, tin, gold, and silver work, enamels, jewelry, and arms; carpets, kincobs, and other textile fabrics, still blazoned with the symbolical figures which mark their descent from the looms of Babylon; and models and other illustrations of processes and manufactures, life, manners, and religion.—*Times.*

GENERAL NOTES.

Edison's Telephone.—An experiment was made with Edison's telephone at Wheal Uny Mine, near Redruth, on 31st ult. The wires were lowered down the old engine shaft to the adit level, 26 fathoms below the surface, and one instrument was fixed at the *adit plat* and the other in the account-house. Mr. Ingall, the representative of the Edison Telephone Company and others, who were underground, conversed freely with Captain Rich, the manager of the mine, and some friends, at the surface, in spite of the roar of the stamps near the account-house and the noise of splashing water in the adit. Orders for timber, dynamite, and borers were sent up, and understood without difficulty. It was agreed that the sounds were far louder than those of the Bell telephone, which some of the experimenters had previously tried in a mine, but the Edison machine did not seem to reproduce the *timbre* of the voice quite so accurately as the Bell instrument; in other words, it was not so easy to recognise the voice of a speaker. Mr. Ingall, however, says that with a little practice the voice is recognised at once. It is probable that further trials will be made in Cornwall. The instrument used was one of the ordinary office telephones, but for mining purposes a louder instrument could be supplied if necessary. Whether the instrument will ever be largely used in mines remains to be seen; but in certain cases it would obviously be of much service, especially where the only means of ascending and descending are by ladders.

Automatic Postal Indicator.—At the late Croydon Sanitary Conference was exhibited a contrivance for the purpose of indicating on pillar post-boxes the time of the next collection of letters. The indicator is the invention of Mr. Thomas Ollis, of Liverpool, and is said to have been for some time in use at Manchester and Liverpool. It is worked when the door is closed by the collector, so that the person about to use the box can see at once whether or not the collection for which he intends his letter has already been made.

NOTICES.

MEETINGS FOR THE ENSUING WEEK.

TUESDAY, NOV. 18TH...Civil Engineers, 25, Great George-street, Westminster, S.W., 8 p.m. Mr. Charles John Wood, "Tunnel Outlets from Storage Reservoirs."

Statistical, Somerset-house-terrace, Strand, W.C., 7.45 p.m. Inaugural Address by the President, Mr. Thomas Brassey.

WEDNESDAY, NOV. 19TH...**SOCIETY OF ARTS**, John-street, Adelphi, W.C., 8 p.m. Lord Alfred S. Churchill, Opening Address of the 126th Session.

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Rev. T. A. Preston, "Report on the Phenological Observations for 1879." 2. Dr. John Robb, "The Meteorology of Zanzibar, East Africa." 3. Lieut. H. H. Russell, "The Sand Storm of July 16th, 1878, at Aden."

Geological, Burlington-house, W., 8 p.m. 1. Mr. J. W. Hulke, "Supplementary Note on the Vertebræ of *Ornithopsis*, Seeley (= *Eucamerotus*, Hulke)." 2. Mr. John Phillips, "The Concretionary Patches and Fragments of other Rocks sometimes contained in Granite." 3. Mr. George Blencowe, "Certain Geological Facts witnessed in Natal and the Border Countries during Nineteen Years' Residence."

Public Analysts, 79, Great Tower-street, E.C. 1. Mr. O. Hehner, "The Mineral Constituents of Cinnamon and Cassia." 2. Mr. G. W. Wigner, "The Determination of Carbonic Acids in Carbonates." 3. Mr. A. H. Allen, "The Examination of Coffee." 4. Dr. Tripe, "Note on the Discrimination of the Starches by means of Polarised Light."

Archæological Association, 32, Sackville-street, W., 8 p.m. 1. Rev. S. M. Mayhew, "Antiquities of the Isle of Man." 2. Mr. Thomas Morgan, "Results of the Yarmouth Congress."

Society for the Development of the Science of Education, Memorial-hall, Farringdon-street, E.C., 7.30 p.m. Rev Dr. R. Morris, "Grammar."

THURSDAY, NOV. 20TH...Royal, Burlington-house, W., 8.30 p.m. 1. Dr. De La Rue and Dr. Hugo Müller, "Experimental Researches on the Electric Discharge with the Chloride of Silver Battery." 2. Prof. W. N. Hartley and Mr. A. K. Huntington, "Researches on the Action of Organic Substances on the Ultra-Violet Rays of the Spectrum" (Part 3), "Examination of Essential Oils." 3. Lord Elphinstone and Mr. C. W. Vincent, "Preliminary Note on Magnetic Circuits in Dynamo and Magneto-Electric Machines." 4. Mr. J. B. Hannay and Mr. J. Hogarth, "The Solubility of Solids in Gases;" and other papers by Messrs. C. Tomlinson, C. Schorlemmer, J. W. L. Glaisher, &c.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. H. M. Ward, "Contribution to our Knowledge of the Embryo Sac in Phanerogams." 2. Mr. C. Haddon, "The Extinct Land Tortoises of Mauritius and Rodriguez." 3. Mr. E. J. Miers, "Greenland Crustacea, collected by Mr. E. Whimper, and New Species from the Arctic Expedition." 4. Mr. E. M. Holmes, "Exhibition of Lichens, *Hepaticæ* and *Algæ*, with Remarks on Species."

Chemical, Burlington-house, W., 8 p.m. 1. Mr. A. H. Church, "A Chemical Study of Vegetable Albinism." (Part II.), "Respiration and Transpiration of Albino Foliage." 2. Mr. Spencer Pickering, "Estimation of Manganic Oxide and Potassium Bichromate." 3. Mr. C. T. Kingzett, "Contributions to the History of Putrefaction." 4. Dr. C. R. Alder Wright and Mr. A. E. Menke, "Notes on Manganese Dioxide."

SATURDAY, NOV. 22ND...Trade Guilds of Learning and Social Education League (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. Free Lecture.

Physical Science Schools, South Kensington, S.W., 3 p.m. Dr. Guthrie, "A Retention Image Photometer."

CONTRIBUTIONS TO THE READING-ROOM.

The Council beg leave to acknowledge, with thanks to the Proprietors, the regular receipt of the following Transactions of Societies and Periodicals during the year:—

TRANSACTIONS, &c.

Aeronautical Society, Annual Report.
Amateur Mechanical Society, Journal.
American Chemical Society, Journal.
American Society of Civil Engineers, Transactions.
Art Union of London, Report.
Bayerische Dampfkessel-Revisions-Verein, Bayerisches Industrie-und-Gewerbeblatt
Belgique, Travaux Public de, Annales.
British Association for the Advancement of Science, Report.
British Association of Gas Managers, Report of the Proceedings.
British Horological Institute, Journal.
Charity Organisation Society, Reporter.
Chemical Society, Journal.
East India Association, Journal.
Farmers' Club, Journal.
Franklin Institution, Journal.
Geological Society, Journal.
Geologists' Association, Proceedings.
Index Society, Publications.
India, Geological Survey of, Memoirs, Records, and Palæontologia Indica.
Indian Meteorological Memoirs.
Institution of Civil Engineers, Proceedings.
Institution of Engineers and Shipbuilders in Scotland, Transactions.
Institution of Mechanical Engineers, Proceedings.
Institution of Naval Architects, Transactions.
Iron & Steel Inst., Journal.
Lancashire and Cheshire Historic Society of, Transactions.
Linnæan Society, Journal and Transactions.
Liverpool Literary and Philosophical Society, Proceedings.
Manchester Field Naturalists and Archæologists Society, Report and Proceedings.
Manchester Literary and Philosophical Society, Memoirs.
Manchester Steam Users' Association, Monthly Report.
Meteorological Society, Quarterly Journal.
Milano. Reale Instituto Lombardo di Scienze e Lettere, Rendiconti
Musée de l'Industrie de Belgique, Bulletin.
National Association for the Promotion of Social Science, Sessional Proceedings.
National Indian Association, Journal.
National Life Boat Institution, Journal.
Pharmaceutical Society, Journal and Transactions.
Philadelphia Engineers, Club of, Proceedings.
Photographic Society, Journal.
Physical Society of London, Proceedings.
Quekett Microscopical Club, Journal.
Royal Agricultural Society, Journal.
Royal Asiatic Society, Journal.
Royal Astronomical Society, Memoirs.
Royal Colonial Institute, Proceedings.
Royal Cornwall Polytechnic Society, Report.
Royal Geographical Society, Proceedings and Journal.
Royal Irish Academy, Transactions and Proceedings.
Royal Society, Proceedings and Philosophical Transactions.
Royal United Service Institution, Journal.
Schlesische Gessellschaft für vaterländische Cultur, Jahres Bericht.
Société d'Acclimatation, Bulletin Mensuel.
Société d'Encouragement pour l'Industrie Nationale, Bulletin.
Society of Antiquaries, Archæologia and Proceedings.
Society of Biblical Archæology, Transactions.
Society of Engineers, Transactions.
Society of Telegraph Engineers, Journal.
Statistical Society, Journal.
Victoria Inst., Journal.
Württemberg, Königliche Centralstelle für Gewerbe und Handel, Jahresberichte.
Zoological Society, Proceedings and Transactions.

DAILY.

Sheffield and Rotherham Independent.

WEEKLY.

Agricultural Gazette.
American Architect and Building News.
American Gas Light Journal.
Architect.
Athenæum.
Bombay Gazette, Overland Summary.
British Architect and Northern Engineer.
British Journal of Photography.
British Mercantile Gazette,
Builder.
Building News.
Builders' Weekly Reporter.
Capital and Labour.
Ceylon Observer, and Weekly Summary of Intelligence.
Ceylon Times, Weekly Summary.
Chamber of Agriculture Journal and Farmers' Chronicle.
Chemical News.
Colliery Guardian.
Colonies and India.
Design and Work.
Draper.
Electrician.
Electricité.
Empire.
Engineer.
Engineering.
Engineering and Building Times.
English Mechanic.
European Mail.
Examiner.
Farmer.
Furniture Gazette.
Gardeners' Chronicle.
Gas Lighting, Journal of.
Herapath's Railway Journal
Home and Home.
Hygiène, Journal d'.
India, Times of (overland weekly edition).
Ingénieur Universel.
Inventors' Record and Industrial Guardian.
Irish Builder.
Iron.
Land and Water.
Les Mondes.
Local Government Chronicle.
London and China Telegraph.
London Iron Trade Exchange.
Metropolitan.
Miller.
Mining Journal.
Moniteur des Arts.
Musical Standard.
Musical World.
Nature.
Photographic News.
Pictorial World.
Polytechnic Review.
Produce Markets' Review.

Queen.
Railway Service Gazette.
School Board Chronicle.
Schoolmaster.
Scientific American.
Staffordshire Sentinel.
Statist.
Temperance Record.
Warehousemen & Drapers' Journal.
Whitehall Review.

FORTNIGHTLY.

Art Interchange.
Brewers' Guardian.
Corps Gras Industriels.
Gaceta Industrial.
Ingénieur Conseil.
Jeweller and Metal Worker.
Moniteur de la Teinture.
Publishers' Circular.

MONTHLY.

American Journal of Industry.
American Mail and Export Journal.
Analyst.
Annales du Génie Civil.
Applied Science, Journal of.
Atlantic Monthly.
Boston Journal of Chemistry.
Brewers' Journal and Hop and Malt Trades' Review.
British Trade Journal.
British and Colonial Printer and Stationer.
Building World.
Caterer.
Chemist and Druggist.
Crónica de la Industria.
Education, Journal of.
Educational Times.
Foreman Engineer and Draughtsman.
Geographical Magazine.
Hygiène et de Police Sanitaire, Revue d'.
Ironmonger.
Leather Trades' Circular.
Machinery Market.
Magazine of Art.
Manufacturers' Review and Industrial Record
Mineral Water Trades' Review.
Monatsschrift für den Orient.
Monde de la Science.
Moniteur Scientifique.
Nautical Magazine.
Paper Makers' Circular.
Revue Maritime et Coloniale.
Saddlers, Harness Makers, and Carriage Builders' Gazette.
Sanitary Record.
Stationer.
Sugar Cane.
Symons' Meteorological Magazine.
Tanners and Curriers' Journal.
Telegraphic Journal and Electrical Review.
Textile Manufacturer.
Watchmaker, Jeweller, and Silversmith.
Wine Trade Review.
Workmen's Hall Messenger.

BI-MONTHLY.

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